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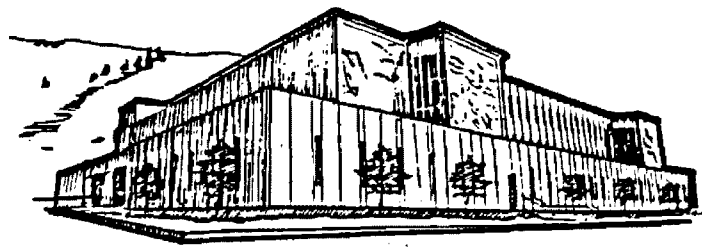
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University of  
**Montana**



**SYMBOLS AND LANDSCAPE:  
THE HISTORY OF PHYSIOGRAPHIC DIAGRAMMING**

**By**

**R. Dennis Leonard**

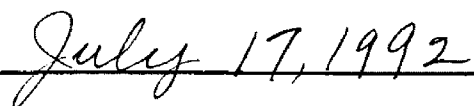
**B.A., University of Montana, 1985**

**Presented in partial fulfillment of the requirements  
for the degree of  
Master of Arts  
University of Montana  
1992**

**Approved by**

  
Chairman, Board of Examiners

  
Dean, Graduate School

  
Date

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Leonard, R. Dennis, M.A. July 1992

Geography

Symbols and Landscape: The History of Physiographic Diagramming (109 pp.)

Director: Paul B. Wilson



There are many methods of depicting topographic relief on maps. Physiographic diagramming is one such method which shows relief with symbols used to represent different types of land forms. It is usually seen on small scale maps but occasionally is found on large scale maps. The purpose of this thesis is to trace the development of physiographic diagramming, ascertain the origins of the form, and determine the major contributors.

This task required the survey and collection of map and diagram data. Several libraries were visited and map information collected on a survey form which was then compiled in a data base. Much historical information from cartographic manuals, journals, text, and interviews with individuals was also collected.

Results showed that physiographic diagramming evolved from individual symbols which were used by some of the first known map makers, the Babylonians and Chinese, to sketch maps and landform drawings, to the renaissance, and the age of exploration, then to block diagrams used in the field of geology to show large scale areas with underlying geology. Armin K. Lobeck is attributed with the invention of the physiographic diagram around the end of World War 1. In this study it was determined that there were three main contributors to the development of physiographic diagramming; Armin K. Lobeck, Erwin J. Raisz, and Guy-Harold Smith. Armin K. Lobeck is attributed with inventing the physiographic diagram. Erwin J. Raisz did the most to systematize and develop the symbols used to produce the diagrams. Guy-Harold Smith produced elegant yet simple diagrams which tended to set the style for most of the physiographic diagrams that have been produced in recent years.

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Most importantly I want to thank my family, Lin for being herself and for being supportive of this endeavor, Vanessa, Melissa, Shawn, and Kaitlin for their curiosity. Ralph and Carol for helping the best they could. Mildred, for help with the children.

## Chapter 1

### Introduction

There are many methods of depicting topographic relief on maps. Physiographic diagramming is one such method which shows relief with symbols used to represent different types of landforms.

One definition states, physiographic diagramming "shows the type of landscape with more or less pictorial symbols which derive from airplane views."<sup>1</sup> This definition is partially correct but not exact. The views are artistic renderings as the artist might draw them while imaging himself in an airplane, on a mountain, or in a satellite. But, they are not actually drawn from these vantage points. Due to the lack of a more concrete definition for this study, physiographic diagramming will be defined as an application of pictorial symbols, at a small scale, designed with license by the cartographer to depict physiography or the physical features of a region or country of the world. Figure 1 shows an example of a physiographic diagram done by Erwin

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<sup>1</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p.149.



Figure 1 Raisz Physiographic Diagram.<sup>2</sup>

<sup>2</sup>From the Raisz collection. By permission of the McGraw-Hill Encyclopedia of Science and Technology.

J. Raisz. Figures 2 and 3 respectively, show a block diagram and a field sketch. When comparing these three figures, one of the similarities noted is that they each depict areas containing landforms, but they do it in substantially different ways. One of the differences is that the physiographic diagram shows a planimetric view of an area at small scale, while the block diagram shows a "perspective of part of the earth's crust on the sides of which the geologic structure is shown and the surface is handled pictorially."<sup>3</sup> Usually, block diagrams depict areas at larger scales than do physiographic diagrams. The difference between physiographic diagrams and block diagrams as opposed to field sketches is that field sketches are usually drawn at even a larger scale; they are not positioned on blocks; and they show features which are portrayed as if viewed from a terrestrial viewpoint. They are picture-like in form since they are viewed from one position.

Each of these types of diagrams is useful for illustrating landforms and terrain. One author, Merrill K. Ridd has indicated that:

. . .the physiographic diagrams of Lobeck, stressing structural influences in terrain information, and the more refined land form map of Raisz, emphasizing the existing product of geomorphic processes, are splendid devices for orienting the viewer to the physiographic patterns of broad regions. Both techniques are based upon the use of symbols to represent general landform types and are de-

---

<sup>3</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 149.

signed for use in small scale map. Generally these maps are drawn at scales less than 1:1,000,000.<sup>4</sup>

Physiographic diagrams are most useful for displaying the landforms of large regions, countries, and even continents. Block diagrams work best for smaller areas which need to be viewed in more detail and for which information about the underlying geologic structure is important. Field sketches are limited to just those features which can be viewed from one spot. They provide the means for their creators to emphasize terrestrial phenomena which would not otherwise photograph well.

Although this paper is not about field sketches or block diagrams, Raisz has indicated that: "physiographic diagramming is an outgrowth of the block diagram."<sup>5</sup> The chronological appearance of the different techniques would further suggest that the block diagram is an outgrowth of the field sketch. Beyond this, various methods of depicting landforms on maps have been used for many centuries. There is ample evidence to support the notion that both block diagrams and physiographic diagrams grew out of these early methods of landform symbolism. Field sketches on the other hand, seem to be more closely related to landscape art. If the development of physiographic diagramming is to be truly understood, all

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<sup>4</sup>Merrill K. Ridd, "The Proportional Relief Landform Map," Annals of the Association of American Geographers. 53 #4 (December 1963) 569.

<sup>5</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book, Co., 1938), p. 149.

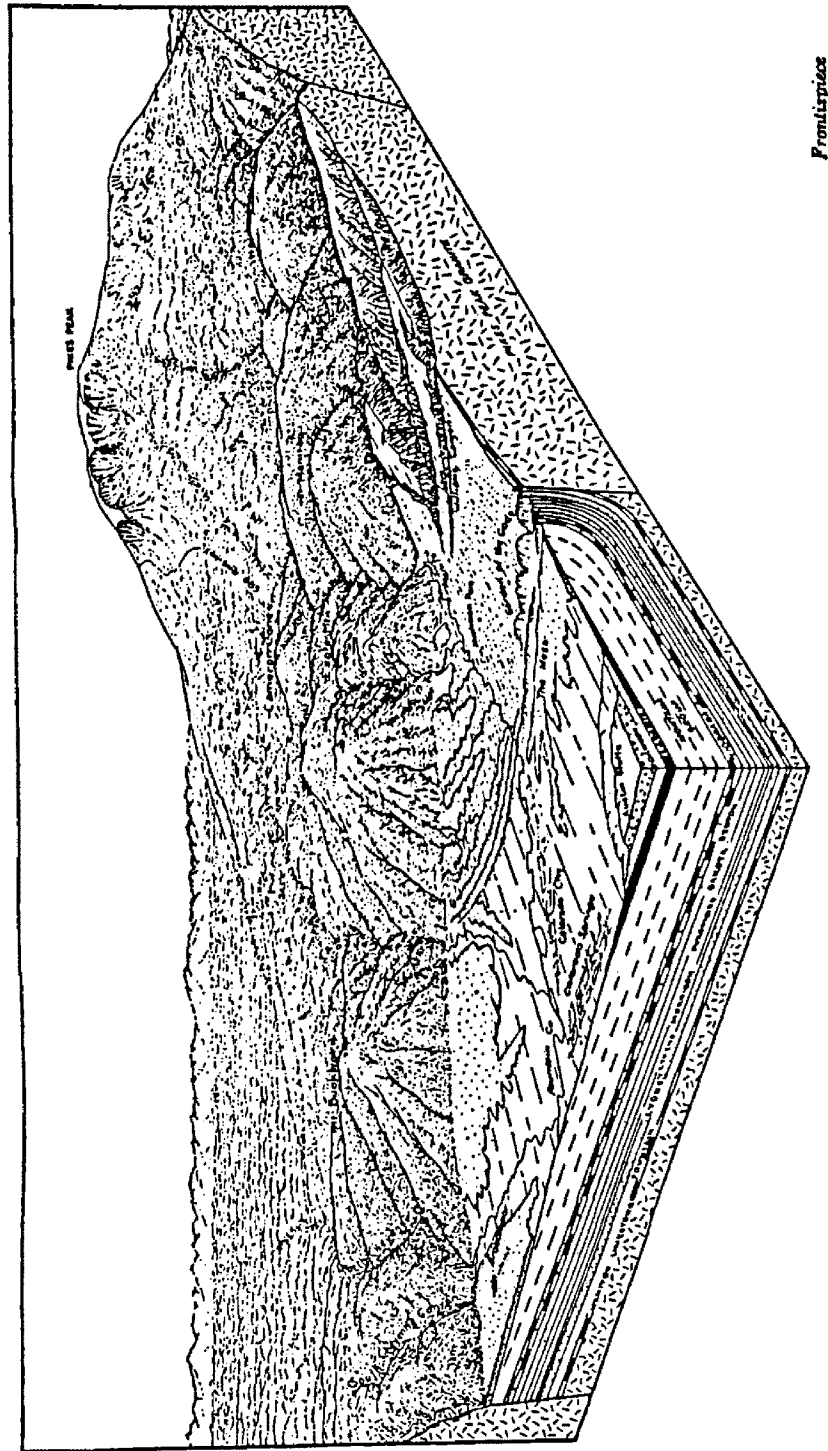


Figure 2 Lobeck Block Diagram.<sup>6</sup>

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<sup>6</sup>Armin Kohl Lobeck, Block Diagrams and other Graphic Methods used in Geology and Geography, 2nd ed. (Amhurst: Emerson-Trussel Book Co., 1958), frontispiece.



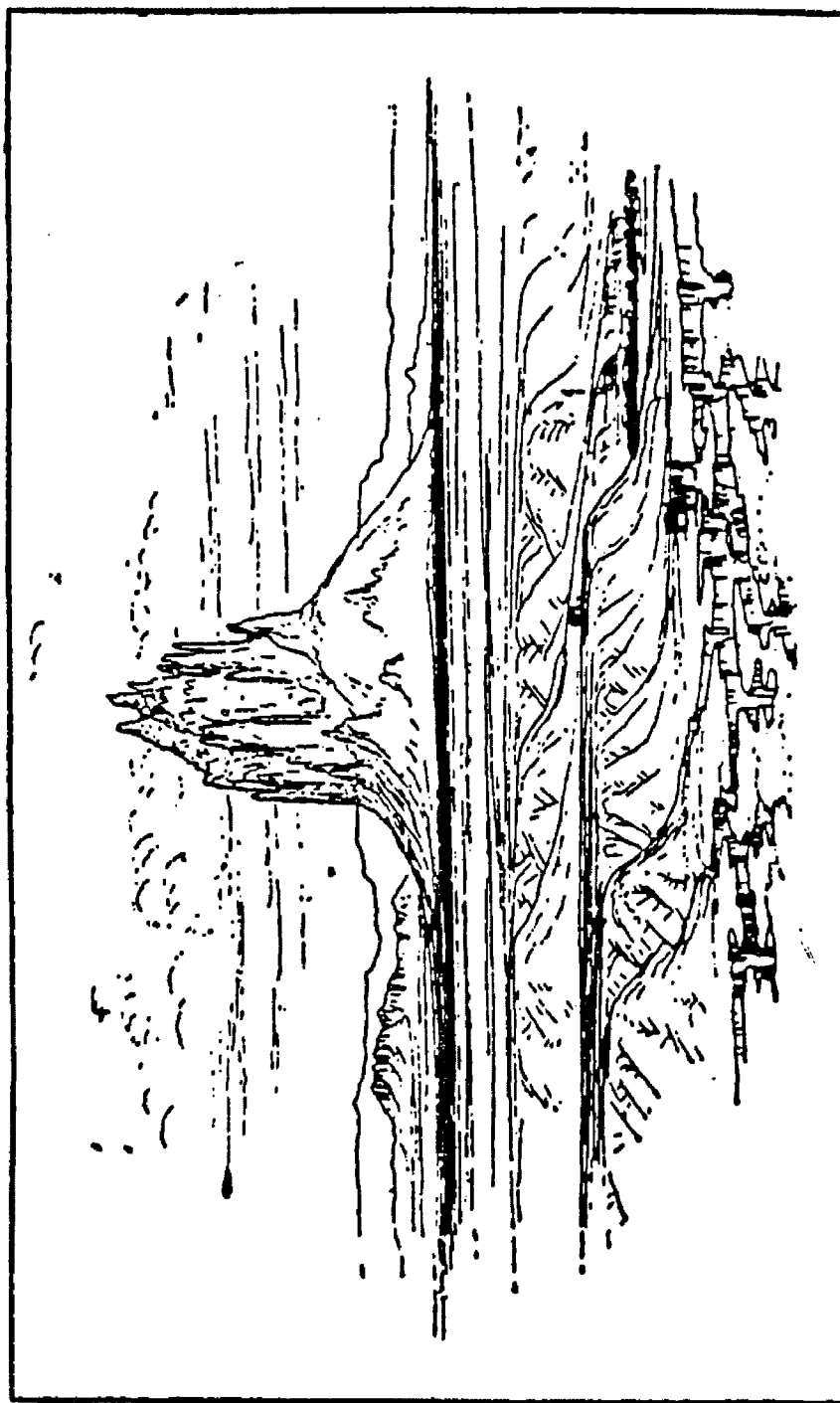


Figure 3    Field Sketch (The Needles)<sup>7</sup>

---

<sup>7</sup>W. H. Holmes, Hayden Report on Colorado and adjacent territories, cited by Armin Kohl Lobeck, Block and other Graphic Methods used in Geology and Geography, 2nd ed. (Amhurst: Emerson-Trussel Book Co., 1958), pg. 179.

antecedent methods of displaying landforms on maps must be examined and their interrelationships investigated.

### **Problem Statement**

The purpose of this study is to trace the development of physiographic diagramming as a form of cartographic expression.

Since physiographic diagramming was invented and most widely practiced in the United States, primary attention is focused on developments in this country. The art form did not evolve spontaneously in America, however. As already noted, physiographic diagramming grew sequentially out of two earlier forms of landscape representation: field sketches and block diagrams. These in turn were fashioned from various methods of symbolic terrain representation, the roots of which can be traced through history, even far back into antiquity.

Understanding physiographic diagramming first requires its antecedents to be explored. Consequently, the study begins by briefly outlining the history of cartography. From this outline, the sequence of inventions relating to the symbolization of terrain is extracted, thus revealing the roots of physiographic diagramming.

Later in the study, even greater attention is devoted to the development of field sketches and block diagrams largely because several of the individuals involved in their develop-

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(Amhurst: Emerson-Trussel Book Co., 1958), pg. 179.

ment were also involved with the origin of physiographic diagramming. The development of each of these three art forms seems to be part of one continuing process. It would be inappropriate to isolate just one of them without considering the others.

Finally, the development of physiographic diagramming in the United States is studied from several viewpoints. The people involved in its development are introduced and their contributions are recounted. Where appropriate, biographical data are included. As many of the physiographic diagrams produced in this country as could be found were examined during the course of research. Their attributes and qualities are summarized in this study; copies of numerous diagrams, each exhibiting different characteristics, are included. The symbols used to create physiographic diagrams are categorized, tabulated, and enumerated in order to define physiographic diagramming more precisely and to describe the manner in which it developed more clearly.

## **Methods**

The research used in this study is primary, however the sources of data are secondary since they were obtained from libraries in the form of already published maps, journal articles, and books. Several different libraries were visited during the course of the study including the University of Montana Mansfield Library, the University of Wisconsin Madison

Memorial Library Rare Book Collection, the University of Wisconsin Madison Geography Library, the University of Wisconsin Madison Robinson Map Library, the U.W. Madison Historical Society Library, University of Wisconsin Geology Library, and the University of Wisconsin Milwaukee Library-American Geographical Society Map Collection.

Table 1, titled "The History of Cartography," which appears on pages 16-20, was compiled from several published sources. It was designed to show the development of cartography from the beginning to present day and was used extensively to help organize the information in chapter two. It allows the reader to browse through cartography from its inception to the present and in the process extract the major developments involved in terrain representation.

A systematic way of collecting, organizing, storing and retrieving mapped information was needed in order to summarize the various attributes and qualities of physiographic diagrams. Consequently, a survey form<sup>8</sup> appearing on page 77 was constructed to aid in this task. Information, discovered through researching cartography, geology and geography books, and various map collections was catalogued on the survey

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<sup>8</sup>At the start of this project the author created a map survey form, fig. 19, p. 77, which targeted specific data for collection. This survey form was then pretested on ten physiographic diagrams and upgraded until the correct information was being targeted.

Information was collected by searching through bibliographies of cartography, through maps, through geology and geography books.

forms. A database management program, Dbase 3+, was used to store, organize, and retrieve all of the survey information for later comparison and analysis.<sup>9</sup>

The development of physiographic diagramming was researched in greater depth; the contributions of cartographers involved have been described and brief biographies given.

The different symbols used on each physiographic diagram examined during the course of the study were inventoried and entered into the computer along with other information such as the date, the cartographer, the publication source, and the library. This information was used to determine when the various new contributions to physiographic diagramming were made, what these contributions were, and who made them.

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<sup>9</sup>Dbase 3+ owned by Ashton-Tate Corporation 1986. This is a database management program used to store, organize, access, and output whatever information the author would choose, i.e. all the information from all the surveys could be printed or just one survey question and its answer from all the forms could be called up. This was used to save the time spent in searching for single bits of information.

## **Chapter 2**

### **History of Terrain Mapping**

#### **Overview**

Although physiographic diagramming is a cartographic technique of the twentieth century, its beginnings may be traced back to ancient times. Attempts were made to depict landforms and other physical features on some of the earliest maps which still exist today. Part of the purpose of this chapter is to trace the development of terrain mapping from its inception to the present. From this, the development of physiographic diagramming will be placed in context with corresponding forms of cartographic symbolization. Similar to the way an individual can only be understood by knowing something of his or her ancestors, physiographic diagramming can only be understood through a knowledge of the similar cartographic techniques which preceded it.

Several steps will be involved in examining the ancestral forms of terrain mapping and in tracing the development of physiographic diagramming. First, the history of cartography will be outlined as briefly as possible. Each new development

in terrain mapping will be emphasized and its particular contributions to physiographic diagramming will be noted. A chronological table will be utilized to aid in this process. Next, the innovations of field sketches and block diagrams will be examined in greater depth. These are the immediate precursors of physiographic diagramming and therefore play an important role in the origin of the concept. Finally, the evolution of physiographic diagramming itself will be examined.

In many regards, the events associated with the development of physiographic diagramming are less important than the people involved. Only a few individuals were responsible for inventing the concept and for embellishing it with a variety of symbols and production techniques. Consequently, the part of this chapter which is concerned with the establishment of physiographic diagramming as a new cartographic art form will be organized mainly around the contributions of those individuals who did the most to promote its development. Examples of their maps will be included, and their major accomplishments will be noted along with other appropriate biographical information.

### **The Development of Terrain Mapping in the Course of Cartographic History**

From the start maps have been more than just simple collections of travel directions. They emerge at the dawn of history as full blown instruments capable of communicating

complex spatial relationships. From that time forward their evolution has been intricately associated with almost every new advance in art, science, and technology.

Viewed in its development through time, the map is a sensitive indicator of the changing thought of man, and few of his works seem to be such an excellent mirror of culture and civilization.<sup>10</sup>

Map making is a form of communication which probably preceded writing: "No one knows when the first cartographers prepared the first map."<sup>11</sup> This seems to be proven by the numerous instances in which early explorers and travelers discovered primitive peoples with no writing skills but with the ability to create maps. The Marshall Islanders and Eskimos created such works; they developed forms of maps which served as accurate and practical navigation tools.

The oldest known map is a Mesopotamian clay tablet from Ga-Sur, an archeological site located about 200 miles north of the city of Babylon. This tablet (Figure 4) has been dated at approximately 2500 B.C. and is thought to depict an estate in present-day Northern Iraq. Even at this early time, symbols were being used to depict landforms, usually mountains. In this example mountains were shown with symbols that look a little like fish scales. In early times these tablets or maps

---

<sup>10</sup>Norman J.W. Thrower, Maps and Man (Englewood Cliffs: Prentice Hall, 1972), p. 1.

<sup>11</sup>Arthur H. Robinson et al., Elements of Cartography, 5th ed. (New York: John Wiley and Sons, Inc., 1984), p. 20.



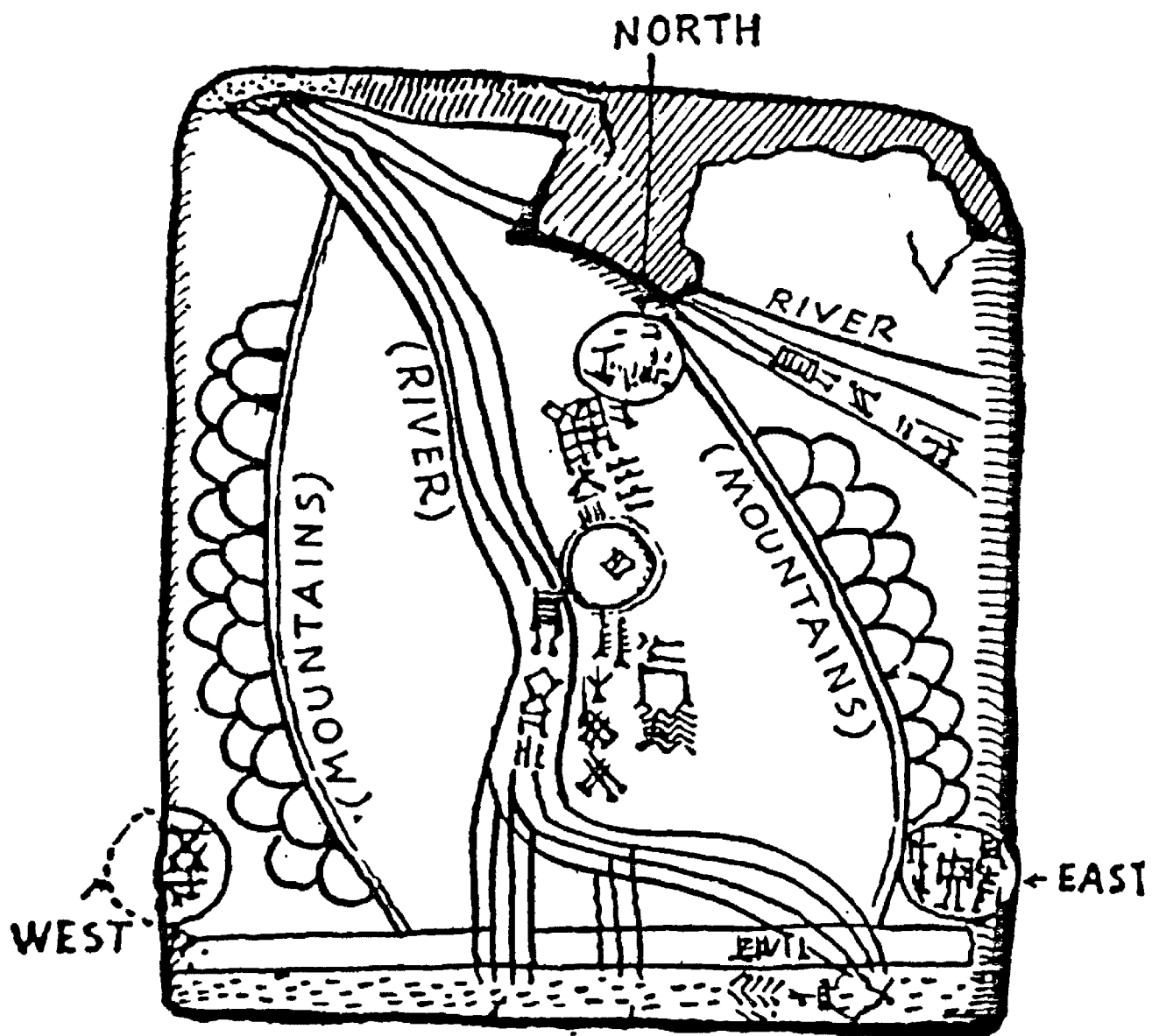


Figure 4 Clay Tablet, 2500 B.C.<sup>12</sup>

<sup>12</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 10.

were probably used to aid in the collection of taxes. This map existed through the millennia only because it was made of durable material and lay undisturbed. One may only conjecture on how long less permanent forms of maps had existed previously. Although this map is quite interesting, Babylon's main contribution to cartography was the subdivision of the circle into units of measurement. This ultimately led to the present measurement of 360 degrees of arc, where one degree equals sixty minutes, and one minute equals sixty seconds. Of course, this measurement system is fundamentally important to map making.

Although no Phoenician maps have survived,<sup>13</sup> it is most probable that the Phoenicians, who obtained much of their culture from the Babylonians, also created similar maps. A chart made by Marinus of Tyre in A.D. 120 (see Table 1), as told by Ptolemy, is thought to have employed early Phoenician material. This material subsequently influenced the Greeks.

The Egyptians, who are thought to have invented the art of land surveying, compiled maps to aid in gathering taxes. Their maps are the first cadastral maps known to have existed.

It appears that the Chinese made several major contributions to cartography Pei Hsiu (224-273 A.D.), the father of Chinese cartography, was the first to use a grid superimposed

---

<sup>13</sup>It is thought that Hanno circumnavigated Africa.

Antiquity					Middle Ages					
600	500	400	300	200	100	0	100	200	300	400
*Chaldean influence										
*-----*Anaximander-credited for 1st map. Disk-shaped Earth.										
*Hanno-circumnavigated Africa										
*Hecataeus-Geography										
*Scylax of India										
*-----*Herodotus-travels										
*-----*Democritus-Longitude and Latitude										
*Aristotle and Pythagoras-Idea of Spherical Earth zones.										
*Pytheas-measured latitude of Masillia, reached British Isles, Discovered Thule										
*-----*Dicaearchus Diopter-measurement of mountains in Greece, 1st parallel										
*Alexander the Great										
*Aristarchus-solar system										
*-----*Eratosthenes-1st measurement of the Earth										
*Hippocrates 7 climates (eudoxas)										
*Crates										
*Polybus-founder of the Roman map										
*-----*Posidonius-measurement of Earth										
*Thales-Gnomonic projection.										
*Argrippa-Map of the Roman Empire.										
*-----*Strabo-Geographia (the main source book for geography, 19 A.D.)										
*Pomponius Mela-Cosmography.										
*Roman Map.										
*-----*Ptolemy-Geography with 8000 place names, atlas of 24 maps, geocentric system of planets, conic projection and Ptolemy's map.										
*Pynax of Dionysius Periegeles.										
*Marinus of Tyre-System of geography. Plain chart-Cylindrical.										
*Sererius-tablet of Rome.										
*-----*Pai Hsiu-Map of Chinese Empire, principals of cartography.										
*Solinus-Memorabilia										
*Peutingar tables										
*St. Hieronymus 388 maps										
*Macrobius-zone maps.										
*Julius Honorius-excerpta.										

Table 1 Chronology of the History of Cartography

Table 1 Chronology of the History of Cartography

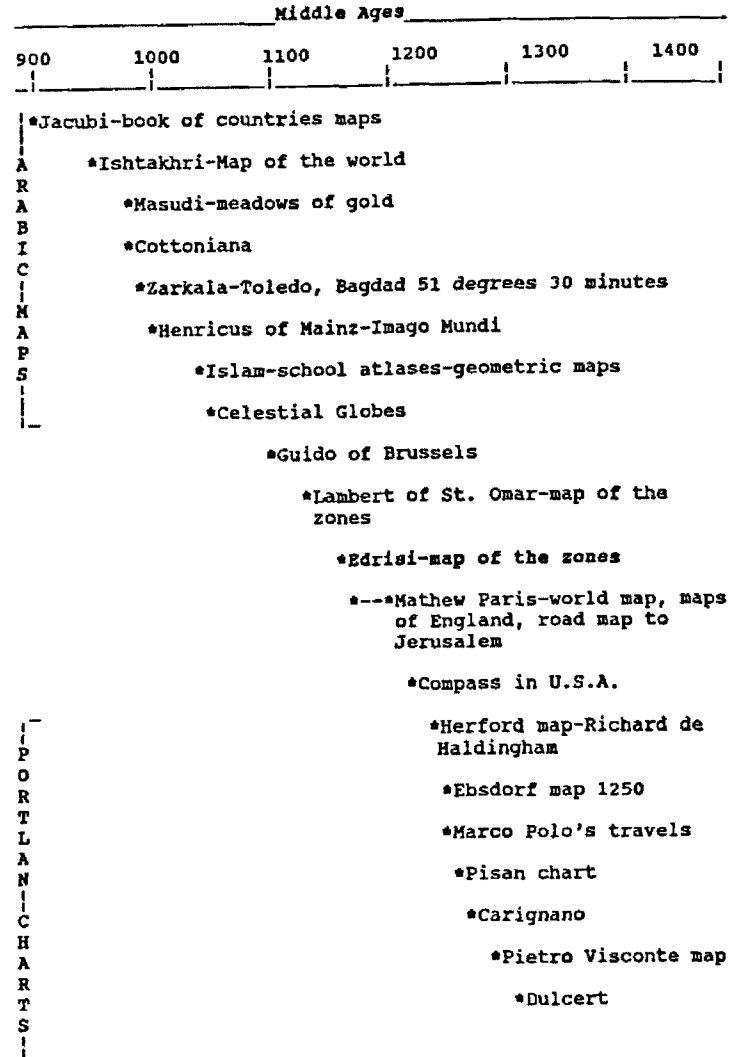
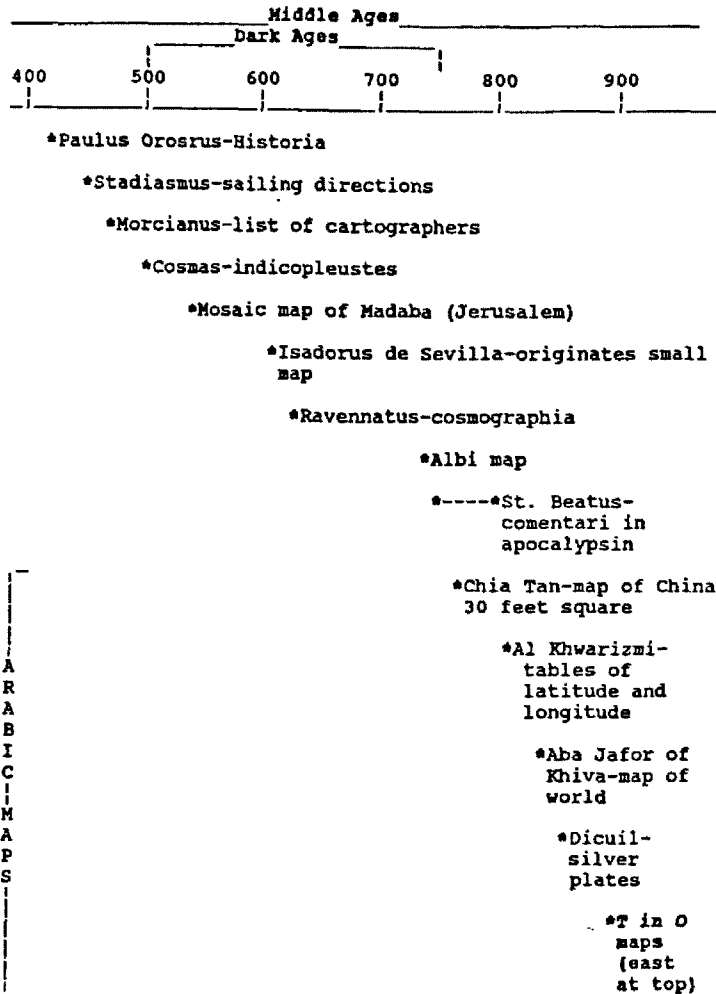


Table 1 Chronology of the History of Cartography

	Renaissance		
	1300	1400	1500
A G E O F T H E P O R T O L A N C H A R T S	*Catalan atlas		
	*Atlante Mediceo		
	*Pierre De Ally's maps-Latin translation of Ptolemy. Claudius Clavus (salarte)-map of Scandinavia.		
	*Benedictine maps and Cusa map of central Europe.		
	*-----*Portolan Charts-various families		
	*Leardo map 1408		
	*-----*Nicolas Germanus-Trapezoidal projection (donis) and modern version of Ptolemy's map for woodcuts.		
	*Fuamauro map-circular world maps.		
	*Buondelmonie Isolario-Agean		
	*Andreu Bianco-Atlas 1436.		
	*Portuguese travels		
	*Engraving and Printing		
	*Martellus Germanus-cusa map and world showing Portuguese discoveries.		
	*Behaim-1st detailed globe based on Ptolemy.		
	*Discoveries of America and a path to India. Iacosa-world map, Contarini-world map, Stabius-Werner projection. Waldsmuller-wallmap of Europe and cordiform projection. Strassburg Ptolemy-20 modern maps.		
	*Carta Marina-12 sheets, J. Schoner-globes		
	*Magellan's voyage		

	Renaissance		Modern
	1500	1600	1700
	*Diego Ribero map		
	*Apianus map		
	*J. Fernel-length of an arc		
	*-----*Gerardus Mercator-world		
	*Copernicus-solar system, DeCastro-harbour charts, DeCrate-maps of America, Sebastian Munster-cosmographia 1544.		
	*Digges-invents theodolite (1570). Ortelius-Theatrum Oribis Terrarum (1570). Drake's voyages.		
	*----*French Arques school-maps and atlases, Lafreri-atlas of Rome, Gastaldi-Asia, Nicolaus-Atlantic Ocean, Medina-maps of Spain. Invention of the Plane table, Mercator projection of the World map with 2 standard parallels.		
	*Hudson and Champlain voyages. Crescantio-navigation books/tides. Hondius-Mercator's successor. Cartaro-13 charts of South Italy. Pisani-globes, Snellius-globes.		
	*Janszon Blau-atlas (1631-1645).		
	*Tasmans voyage (Toricelli-barometer), Kircher-chart of Magnetic Variation, subterranean currents.		
	*W. Sanson-French charts.		
	*Pendulum clock, Sea atlases-Donckers, VanLoon, P.Goos, Picard-length of an arc, longitudes, use of the telescope, N. Sanson-Flamsteed Sinusoidal equal area projection.		

Table 1 Chronology of the History of Cartography

Modern	
1700	1800
*1683 Edmund Halley-isolines magnetic declination.	
*Newton-spheroid. World polar projection. Cassini-measurment of longitude at the French Academy of Science.	
*---*G. Delisle-Reduction of the Mediterranean to 42 degrees, of America, Secant Conic projection, Ferro meridian royal order. First contour lines. Octant-Hadley (1931). J.B.B. D'Anville-history of geography. Coast survey-Peter the Great.	
*Chronometer-J. Harrison. Kirilov atlases. Triangulation of France (1734-1744).	
*Cassini-carte de geometrique de la France 1:86,000. First U.S. State surveys. LaCondamine measurment of the arc of Peru. Philip Buache (delisle successor) contour lines in the English Channel. Earth as an Ellipsoid. Tobais Mayer-longitude by tables of the moon. Russian Academy atlas (19 sheets). Rigobert Bonne (Bonne projection, 1765). Devagondy-atlas Universelle globes and atlases.	
*Cook's voyage. Lambert and Euler projection- Cylindrical equal area, conic conformal, Azimuthal equal area, Transverse Mercator. Triangulation of England, ordinance survey. Lithography for maps.	
*Ramsden-theodolite. Metric system. Triangulation of Belgium and Paris. 1000 survey of India. Lehman system of Hachuring. Washington surveys.	
*---*British Military surveys. Earliest U.S. mapmakers, atlases. West coast surveys. Mackenzie in Canada. Humboldt in U.S.. Napoleon's survey of Europe, Tranchot and Morreau 1:1,000,000. Justus Perthes-Gotha, mapmaker and printer (1786).	
*-----*Tanner-new American atlas. U.S. Army surveys. South and West coast surveys.	
*1790 Contour Maps French Military.	

Modern	
1800	1900
*---*Karl Ritter-Erdkunde (1817). Alexander Von Humboldt-atlas of New Spain, Isotherm map (1st Thematic map?). William Smith-geologic maps. Lewis and Clark expeditions. William McClure-geologic maps of the U.S.. Gauss projection?.	
*---*Photoengraving and color printing-Julius Bien.	
*Wax engraving. Mollwiede Homolographic projection.	
*Mitchell atlas. Heliogravure-photoincography.	
*Dufour-maps and atlases (1860). U.S.G.S..	
*County, city and state atlases.	
*Photogrammetry.	
*---*Eckert projections-Albers and polyconic. Vandergrinten projection. Howells and Curtis-high grade topogaphic projection. William M. Davis-block diagrams. Paul Goode-Interrupted projection, school maps. International map of the World-proposed by Albrecht Penek (1891) accepted in 1909, scale of 1:1,000,000.	
*D. W. Johnson-Battle Fields of the World War (Lobeck, Morris and Knight).	
*Echosounding. Airplane photography. Miller cylindrical projection. Fuller dymaxion. World Areonautical chart (WAC) completed at 1:1,000,000. Physiographic Diagramming (Lobeck, Raiss and G.H. Smith).	
*Invention of the first electronic digital computer. ENIAC-first genral purpose electronic digital computer (U.S.Army funded).	
*---*Advances in graphic and production methods.	

Modern	
1900	
2000	
	<ul style="list-style-type: none"> <li>*-Sputnik 1-first satellite (U.S.S.R.).</li> <li>Vanguard 1-first satellite, showing a pear shaped earth. Start of satellite use for triangulation across ocean.</li> <li>SYMAP-one of the first computer mapping programs (1963).</li> <li>*Map of the Moon and Mars. Landsat imagery used to map the U.S. at a scale of 1:1,000,000. Dawn of Geographic Information Systems (GIS).</li> </ul>

Table 1 Chronology of the History of Cartography<sup>14</sup>

<sup>14</sup>Information for this table was compiled from several tables in the Raisz text: Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), pp. 15, 25, 36-37, 52-53. This information was then presented in a more usable format. The following works were used in verification of the Raisz table; Norman J. W. Thrower, Maps and Man (Englewood Cliffs: Prentice Hall, 1972); G. R. Crone, Maps and their Makers (London: Hutchinson & Co. LTD., 1953, reprinted ed. 1964); R. V. Tooley, Maps and Map-Makers (Great Britain: Bonanza Books, Crown Publishers, Inc., 1970); R.A. Skelton, Maps A Historical Survey of Their Study and Collecting (Chicago: University of Chicago Press, 1972).

over a map. Although not measured in degrees of latitude or longitude, the grid was useful in calculating scale and locational measurements. In many ways China was ahead of the Western world; for example, paper had been invented in A.D. 100.<sup>15</sup> There is evidence that a reference to a south-pointing chariot, which alludes to a magnetic indicator appears on a map dating back to the Wei Dynasty in the third century A.D.. This is likely the first time an arrow was used to depict magnetic direction. The earliest known printed map of China (1115 A.D.) predates the first map printed in Europe by three centuries.

The Greeks were the first to attempt mapping the entire known world at small scale. They came to an understanding of the spherical shape of the earth with its poles, equator, and tropical zones. They were the first to invent a system of location which employed parallels and meridians. They designed the first map projection (see Table 1); they made the first estimates of the size of the earth through mathematical calculation. The cartographic knowledge that we possess concerning the ancients comes mainly through the collected works of Strabo and Herodotus. Anaximander of Miletus (611-547 B.C.) made the map a "whole circuit of the Earth, every sea and all rivers."<sup>16</sup>

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<sup>15</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938) pg. 12.

<sup>16</sup>Ibid., p. 14.



Hecataeus (500-490 B.C.) improved this disk-shaped map and wrote a systematic description of the world. Aristotle formulated the six arguments used to prove the existence of the equator, the poles, and the tropics. He theorized that the earth was divided into hot, temperate and frigid zones. Eratosthenes of Cyrene (276-196 B.C.), a Greek who was in charge of the library at Alexandria, Egypt, was the first to attempt measuring the circumference of the earth. He came very close to estimating its exact size. He also created a world map using seven parallels and seven meridians which showed information gathered by Alexander the Great.

Ptolemy (90-168 A.D.), like Eratosthenes, was head of the library at Alexandria. His main interests included mathematical geography, the principles of cartography, map projections, and astronomical observations. Of singular importance to this thesis, he made the next known contribution to the depiction of landforms on maps. His world map included notation for latitude, longitude, and climatic types; it employed a conic projection; and it displayed mountain ranges with symbols which resembled sugar loafs or mole hills (Figure 5). This type of symbol continued to be used on maps up through the middle of the eighteenth century.

Ptolemy is known for one notorious mistake: he miscalculated the size of the earth by adhering to Posidenius's measurement instead of Eratosthenes's. This mistake made the size of the world much smaller than it really is. Either

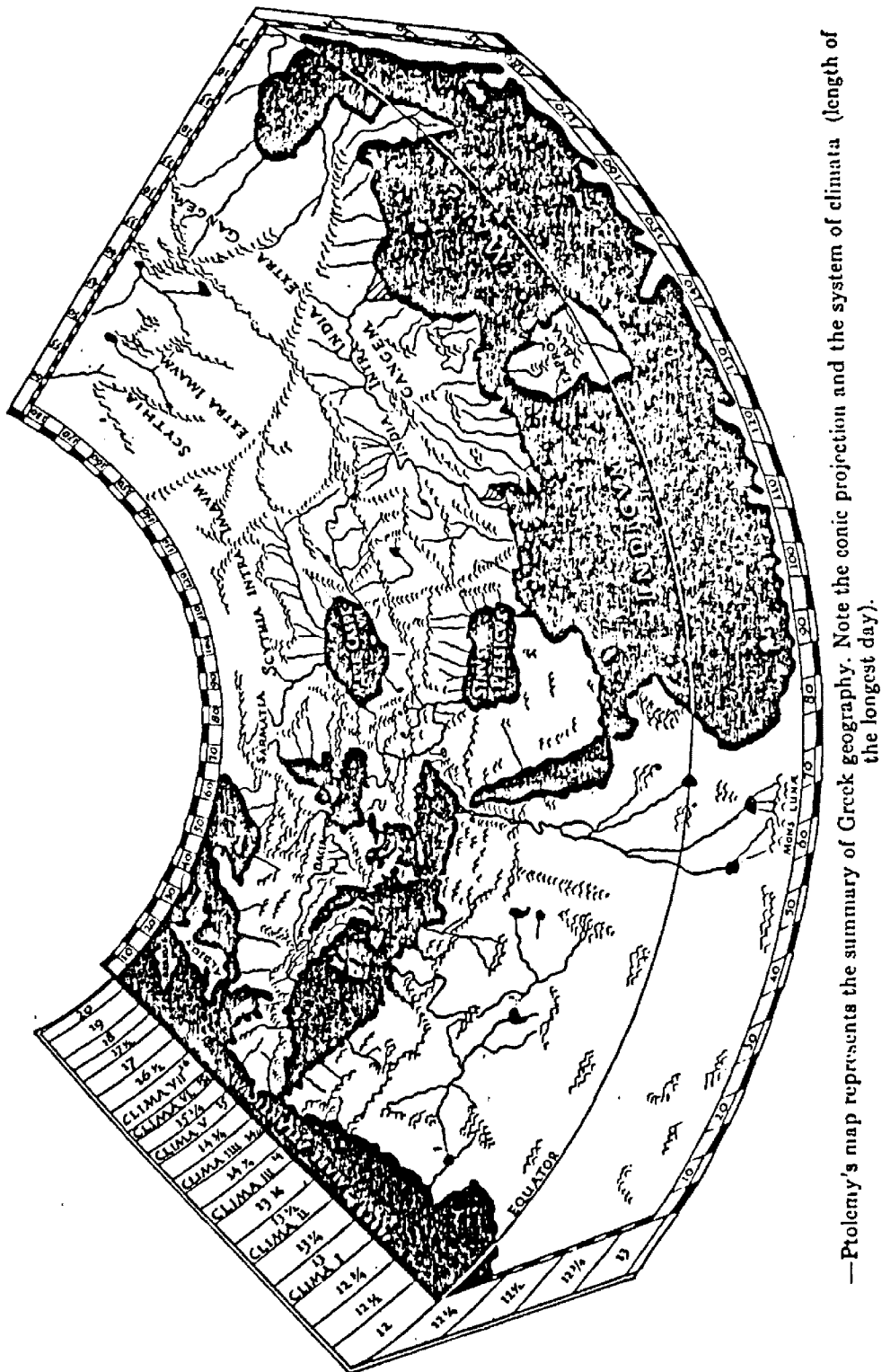
unfortunately or fortunately, as one may view the results, the mistake was copied by European cartographers. Likely, Columbus was lured into attempting to reach Asia by sailing west because of the misinformation; of course, he found the Americas, not Asia. The true circumference of the earth was not entirely corrected until the start of the eighteenth century.

The Romans approached map making differently than did the Greeks. They were not interested in mathematical geography but in maps they could use for military and administrative (cadastral) purposes. The Romans reverted to much earlier disk shaped maps and invented a refined version of them called T-in-O or Oribus Terraum maps<sup>17</sup>. These were used throughout the Middle Ages, often referred to as the circuit of the world. The Peutinger table<sup>18</sup> (Figure 6), a cartogram from the same period in time, is one of the major maps exemplifying cartography as practiced by the Romans. Believed to have been drafted by Castorius in the first century A.D., it is a travel map showing routes, towns, and rivers. It includes many place names and notes regarding mileage and military posts.

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<sup>17</sup>This map usually has east at the top, with Asia occupying the upper half. Asia is separated from Africa by the Nile and from Europe by the Tanais. Together, these two rivers form the top of the T; the Mediterranean, separating Europe and Africa, forms the segment of the T. The whole is surrounded by the ocean O.

<sup>18</sup>Konrad Miller, Die Peutingersche Tafel (Stuttgart F.A. Brockhaus Komm.-Gesch., GmbIt., Abt Antiquarium, 1962).



—Ptolemy's map represents the summary of Greek geography. Note the conic projection and the system of climata (length of the longest day).

Figure 5 Ptolemy<sup>19</sup>

<sup>19</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 19.

Similar to Ptolomy's world map, the Peutinger Table is significant because it attempts to depict terrain. Mountains are shown as shaded profiles, and sea coasts appear much the same. Although a major cartographic work of the time, the Peutinger Table is difficult to decipher; one must either have prior understanding of how to read it or a vivid imagination. Arabic culture, well advanced in astronomy and geography, contributed substantially to the field of cartography. Idrisi's world map (Figure 7) exemplifies the Arabic style of landform portrayal; mountains appear in the shape of loafs.

Cartography in the Middle Ages, as with most things concerning science and technology during this time period, had to conform to contemporary religious beliefs. As a result, map making became dominated by Christian supernaturalism. Maps of the known world that were produced were a vehicle ". . . for preserving the results of fanciful speculation and literal interpretation of biblical passages."<sup>20</sup> Medieval cartographers perfected upon the T-in-O maps the Romans had invented. Some of these maps contained a wealth of information, but most were not laid out in a scientific manner. The Portolan charts were an exception. These accurate maps of coastal features and water bodies were a product of naval officers of the Genose fleet beginning about the second half

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<sup>20</sup>Arthur H. Robinson et al., Elements of Cartography, 5th ed. (New York: John Wiley and Sons, 1984), p. 25.



*Simplified rendering of a small section of the Peutinger Table. Because of the greatly reduced scale of the map, lettering on the boot of Italy and Sicily. Redrawn by Noel Diaz. (which forms an important feature of the original) is omitted.*

Figure 6 Peutinger Table (example)<sup>21</sup>

<sup>21</sup>Norman J.W. Thrower, Maps and Man (Englewood Cliffs: Prentice Hall, 1972), p. 30.

of the thirteenth century. These are relatively accurate navigational charts, some possessing as many as thirty-two compass roses with radiating rhumb lines crisscrossing the map. The Catalan Charts, sometimes called the Catalan Atlas, were the result of compiling the Portolan Charts into one map of the known world. Examples of landforms produced during the Middle Ages do occasionally contain loaf- style mountains, but no other types of landforms.

The renaissance in cartography came about in the late fifteenth and early sixteenth centuries. During this period, landforms were still being depicted as loafs, but they also started appearing as artistic renderings, as is exemplified by the map by Blaeu which appears in Figure 8. On this map, landform renderings show the mountains with shaded relief symbols which are dark on one side and light on the other.

Raisz<sup>22</sup> has indicated that there were three events which contributed to the reemergence of interest in cartography during the renaissance: The rediscovery of Ptolemy's Geographia, the arrival of printing and engraving in Europe, and the age of great discoveries.<sup>23</sup> Although Ptolemy's,

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<sup>22</sup>Erwin J. Raisz General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 29.

<sup>23</sup>Ptolomy's Geographia is an eight volume work. The first volume contains theoretical principles involving techniques of map projection and globe construction. The second through seventh volumes contain listings of 8,000 place names with latitudes and longitudes. The eighth volume contains Ptolomy's discussion of the principles of cartography, mathematical geography, projections, and methods of astronomical observation. This work also



*Portion of Idrisi's world map, with south orientation.*

Figure 7 Idrisi Map<sup>24</sup>

contained a world map and twenty-six other detailed maps.

<sup>24</sup>Norman J.W. Thrower, Maps and Man (Englewood Cliffs: Prentice Hall, 1972), p. 39.

Geographia had been preserved by the Arabs for a millennium, it was not known among European scholars until the manuscript reached Italy and was translated in to Latin in about 1410 A.D. This rediscovery was rather like the double edged sword. Although Ptolemy's Geographia proved a tremendous stimulus to the field of cartography and other fields, the whole document became accepted as truth and much of the sound information concerning the known world that had been added in the interim was set aside.

The second event which stimulated cartography was the arrival of printing and engraving in Europe. This not only reduced the cost of maps but, more importantly, it allowed for the mass production of maps so they became available to all literate people. First, woodcuts were used, then copper

The third event important to the renaissance of cartography was the period of the great discoveries. These were made possible mainly because of several inventions occurring during the late thirteenth and early fourteenth centuries. The magnetic compass was one; superior sailing vessels such as the Flemish Karak and the Spanish Caravel were others. These vessels allowed crews to be smaller in size; they could venture farther away from coasts, carry large amounts of food, and go many days without stopping to resupply.

The first discoveries were those made by the Portuguese. These have been recorded on the Portolan Charts and on Martin





BLAEU'S MAP OF BUCKINGHAM (10½" × 16½")  
from Part IV of the *Theatrum Orbis Terrarum*, 1645

Figure 8 Blaeu Map<sup>25</sup>.

<sup>25</sup>Tooley, R.V. Maps and Map-Makers (New York: Bonanza Books, 1970), p. 66.

Behaim's Globe, the oldest terrestrial globe in existence. engravings were made. Many of the maps produced during the Renaissance were high quality works of art, many of which still grace the walls of museums and art galleries today.

Other discoveries were made by the Spanish, English and the Dutch. Figure 9 shows four maps reproduced by Raisz which depict the development of new discoveries in the early sixteenth century. The first is Lacosa's map produced in 1500. It is the first to show America. The second, a map by Contarini which appeared in 1506, shows North America as part of Asia. The third map, made by Waldseemuller in 1507, is the first map to show the Americas separated from Asia; it was also the first to attach the label "America" to the new found continents after the discovery of the Venezuelan coast by the explorer Amerigo Vespucci in 1499. All three of these maps have longitude measurements based on Ptolemy's estimate which appeared in Geographia. The fourth is Diego Ribero's map drawn in 1529. It was one of the first to show the discoveries of Magellan and shake off the Ptolemaic system of cartography by giving a more correct depiction of the earth's circumference. A comparison between Ribero's map and that of Lacosa shows a large amount of change over a very short period of time. The age of great discoveries proved a very fertile period for cartography.

Gerardus Mercator (1512-1594) (see Table 1) was the "first cartographer to produce a true navigational chart with

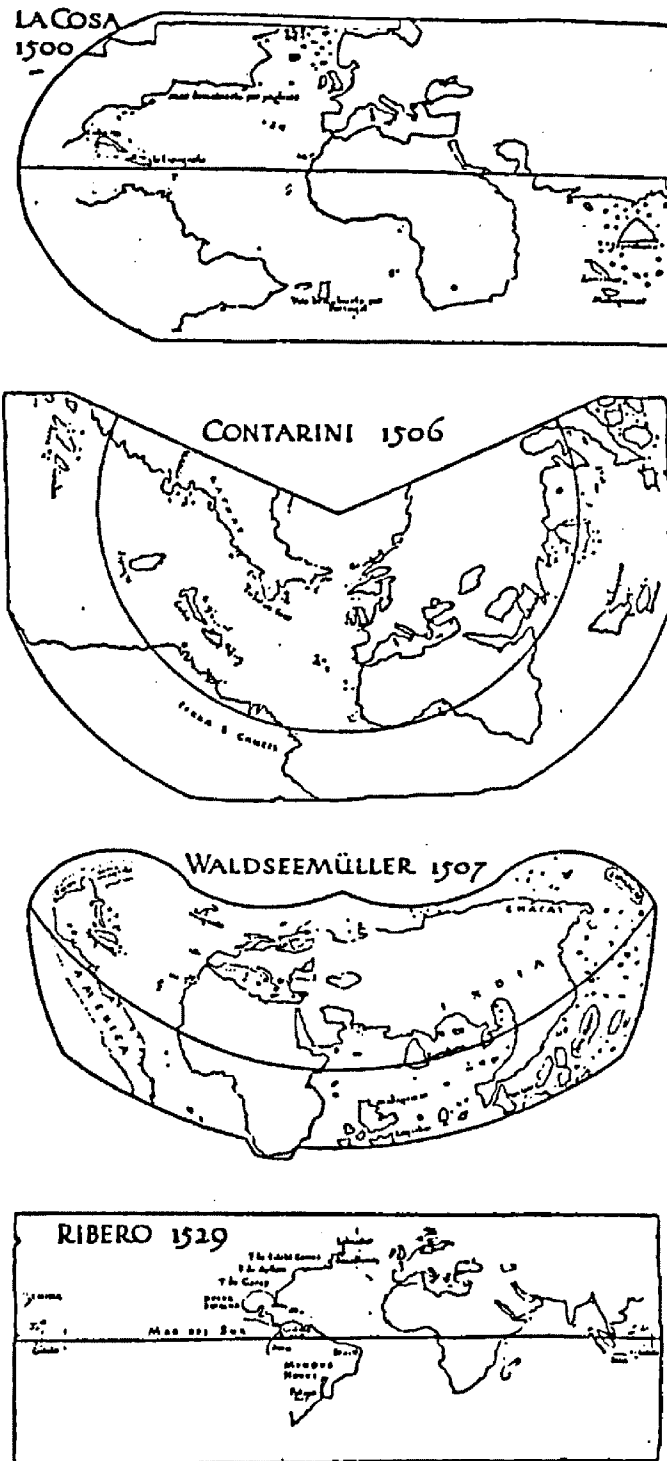


Figure 9 Four progressive diagrams<sup>26</sup>

<sup>26</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 32.

graticule on which a compass line intersects each meridian at a constant given angle."<sup>27</sup> These charts still carry his name and are used for maritime navigation even today. His greatest accomplishment was using this idea to create a world map (1569) in which all of the shapes around any given point are correct (conformal).<sup>28</sup> Also on this map, the straight lines are loxodromes or lines of true compass bearing. One other contribution made by Mercator was to reduce the longitude error of Ptolemy by ten degrees, still not correct, but closer. Mercator worked on a world atlas until his death. It was finished by his son and published in 1595. Ortelius of Antwerp, Mercator's friend and competitor, produced the first bound atlas in 1570; it was called the *Theatrum Orbis Terrarum*. Following Mercator and Ortelius, other notable cartographers also produced atlases, including Hondius, Janszoon, and Blaeu, to name but a few.

A major reformation in cartography began with the accurate measurement of longitude by the French Academy early in the eighteenth century. This was made possible by the invention of an accurate chronometer by an Englishman named John Harrison earlier in that century. The most precise corrections were made by Guillaume Delisle, an outstanding French geographer of the eighteenth century.

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<sup>27</sup>Norman J.W. Thrower, Maps and Man (Angled Cliffs: Prentice Hall, 1972), p. 55.

<sup>28</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 32.

At about this same time, the Cassini family undertook the first national survey in France. The Cassinis were originally from Italy, but they immigrated to France when their founder, Jean Dominique Cassini, became the director of the observatory at Paris in 1671. Jean Dominique's grandson, Caesar Francois, began the survey in 1744. It involved laying out an accurate base line across France from which triangulation was conducted to locate all major topographic features. The work was ultimately published by Caesar's son Jaques Dominique in 1789. It was the first accurate topographic survey to cover an area of national scale. Late in the eighteenth century other countries, following the example of France, started their own land surveys. England, Spain, Switzerland, and several of the German Provinces were among the first. From that time, the effort has spread until most nations have programs for conducting national topographic surveys. The agency responsible for producing topographic maps of the United States is the United States Geological Survey (U.S.G.S.). Topographic surveys were important to the development of terrain mapping because they provided accurate base maps for plotting drainage patterns, mountain peaks, and other landmarks essential for locating landforms.

Terrain mapping began to undergo major developments during the eighteenth century. Major F.G. Lehmann, a Saxonian officer in Napoleon's army, invented a scientific system of shading slopes called hachuring, a method of hill shading

using closely spaced parallel lines.<sup>29</sup> Slopes were shown by numerous short lines. The lines were all equal distance apart and ran straight downhill in the direction water would flow. Steeper slopes were indicated by producing thicker lines rather than utilizing more lines (Figure 10). At first hachuring was mainly used on topographic maps produced for the military. Later it became widely used on all types of topographic maps, road maps, and general location maps published during the nineteenth century. The quality of the hachuring varied greatly. The Dufour maps<sup>30</sup> of Switzerland (Figure 11) were of very high quality; other oversimplified hachure maps would tend to look like hairy catapillars.

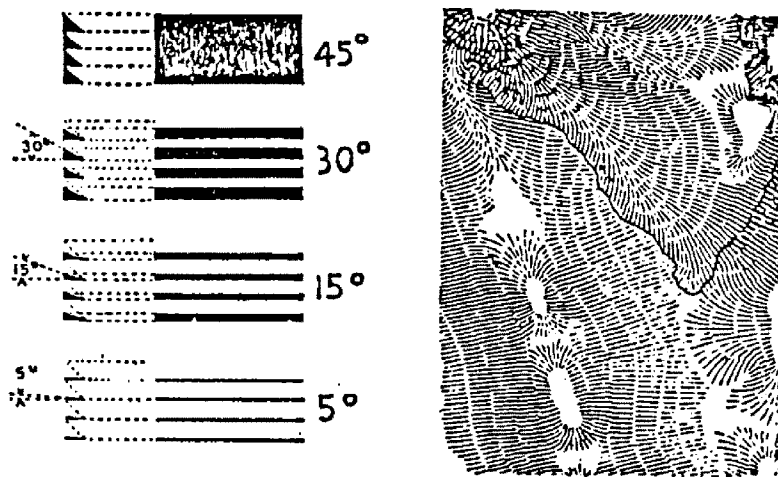
Contour mapping appeared for the first time during the eighteenth century. Actually, the concept had been known for over a hundred years but never applied to mapping terrain. The English scientist, Edmund Halley, had produced a map which employed isogonic lines in 1701.<sup>31</sup> This was the first map of

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<sup>29</sup>Ibid., p. 124.

<sup>30</sup>G. H. Dufour created the atlas of Switzerland, published in the mid-nineteenth century.

<sup>31</sup>Isogonic lines are isolines representing equal magnetic declination (Figure 12). Isolines are lines used in mapping which have equal value along their entire length--the values may concern any thematic variable. Isobars are isolines which connect points of equal barometric pressure, isotherms connect points of equal temperature, contours connect points of equal elevation above sea level, and so on.



—Lehmann system of hachuring. The lines on the left are strongly magnified.

Figure 10 Lehman Map<sup>32</sup>



—Hachuring with oblique illumination is effective in mountainous country.  
(From the Dufour map of Switzerland.)

Figure 11 Dufour Map<sup>33</sup>

<sup>32</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co., Inc., 1938), p. 125.

<sup>33</sup>Ibid., p.127.

its kind in print.<sup>34</sup> The Dutch engineer, Nicholas S. Cruquius, built a map which employed isobaths, lines of equal depth beneath the surface of a water body, in 1729 (Figure 13).<sup>35</sup> Alexander Von Humboldt, the great German naturalist and scientist, drafted a map employing isotherms at about the turn of the nineteenth century to illustrate research he had conducted during an expedition into Latin America between 1799 and 1804. The first individual to use contours on large-scale topographic maps is believed to be a French engineer named J. L. Dupain-Treil. His map was produced in 1791.<sup>36</sup>

The development of contour mapping had profound effect on mapping terrain features. Valleys, mountains, plains, canyons, and land features could be precisely measured on the ground and represented on the map. No artistic rendering was involved. The contours, when plotted at a common interval, allowed the map reader to interpret or visualize the actual slopes and approximate shape of the land. As a result, mapping terrain with contours became the favored method. Most national surveys ultimately adopted contours to display terrain. The U.S.G.S. uses them for virtually all of the topographic quadrangles that they publish.

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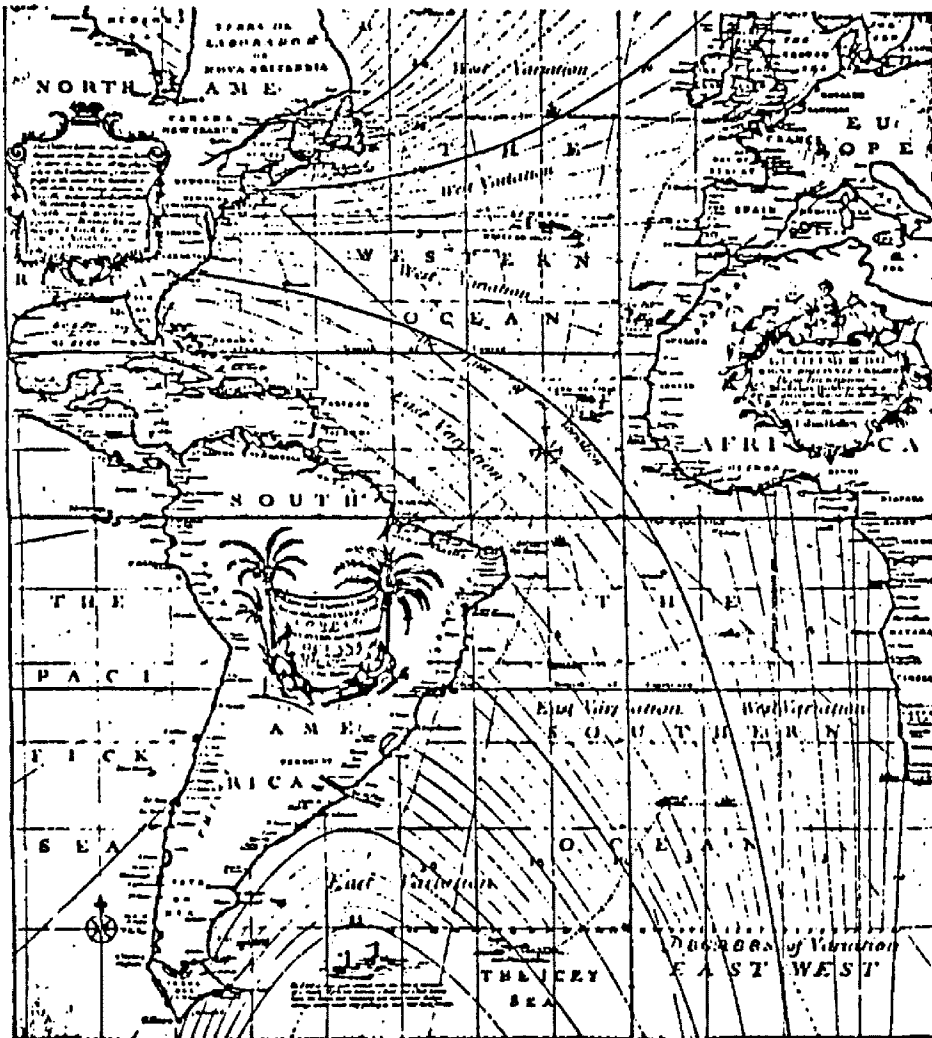
<sup>34</sup>Norman J. W. Thrower, Maps and Man (Englewood Cliffs: Prentice Hall, 1972), p. 65.

<sup>35</sup>Ibid., p. 71.

<sup>36</sup>John Nobel Wilford, The Mapmakers: The Story of the Great Pioneers in Cartography from Antiquity to the Space Age (New York: Vantage Books, 1982), p. 127.



In the nineteenth century, numerous developments pushed cartography forward. With the start of the industrial revolution new advances in the arts of lithography and engraving provided the means for maps and other printed material to be produced at low cost. These new processes aided in the advancement of map making during the 1800's. The invention of photography and color printing, the beginning of the use of statistical methods, the growth of transportation networks, and the start of professional societies also had great impact on map making. Germany became the largest producer of maps and atlases during the nineteenth century; their maps were noted for their accuracy, beauty, and clarity. This period saw the start of the great Western surveys of King, Wheeler, Powell, and Hayden in the United States. Late in the nineteenth century attempts were made to begin to standardize some of the important elements of cartography among the nations of the world. The International Meridian Conference was held in Washington in 1884 with the purpose of agreeing upon a single, prime meridian from which longitude would be measured for all countries. The meridian passing through the Observatory of Greenwich in England was chosen, and longitude was to be reckoned both east and west to 180 degrees which was designated the international date line. At the fifth International Geographical Congress, held at Berne in 1891, Albrecht Penck, a geographer from the University of Vienna, proposed an International Map of the World at



(above) *Isogonic map of the Atlantic (1701) by Edmond Halley.*

Figure 12 Isogonic Map<sup>37</sup>

<sup>37</sup>Norman J. W. Thrower, Maps and Man (Englewood Cliffs: Prentice Hall, 1972), p. 67.

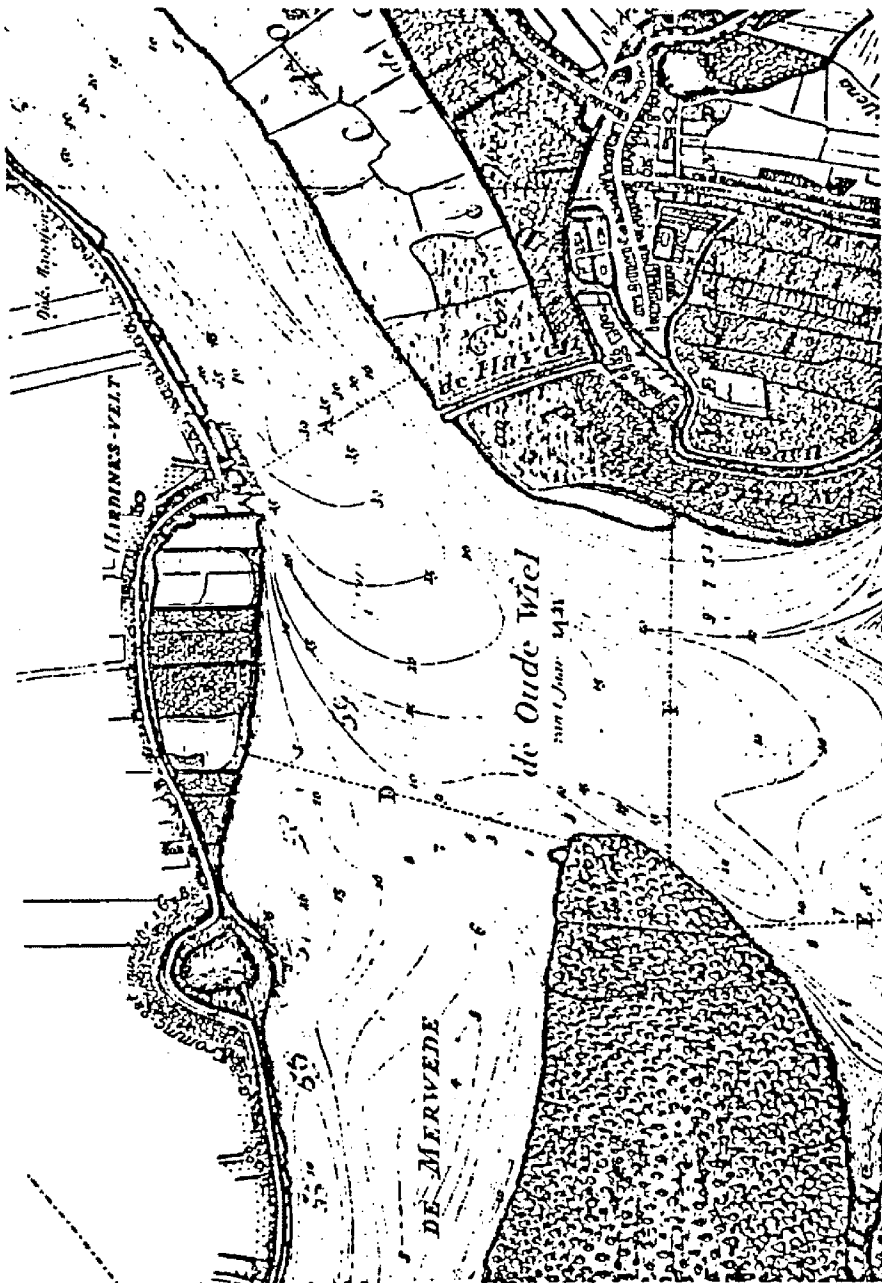


Figure 13 Isobath Map<sup>38</sup>

<sup>38</sup>Ibid., p. 72.

the scale of 1:1,000,000. The idea seemed reasonable, but the debate dragged on until the International Conference on the International Map, held in Paris in 1913, when agreement on the standards for the "Millionth Map" was finally reached.<sup>39</sup>

Although the International Map of the World has only been totally completed by a few of the nations having the most resources, mapping continued to progress to the extent that during the twentieth century virtually every inch of the world's land has been mapped repeatedly at several different scales.

Achievements in mapping to this point in the present century have led Arthur H. Robinson, the Dean of American cartographers, to write:

Cartography has probably advanced more, technically, since the beginning of the twentieth century than during any other period of comparable length.<sup>40</sup>

The advent of the two world wars created a need for precise topographic maps for many areas of the world. Advances were made in photogrammetric plotting instruments and graphic presentation methods which vastly increased the accuracy and decreased the time involved in producing maps.

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<sup>39</sup>John Nobel Wilford, The Mapmakers: The Story of the Great Pioneers in Cartography from Antiquity to the Space Age (New York: Vantage Books, 1982), pp. 220-222.

<sup>40</sup>Arthur H. Robinson et al., Elements of Cartography, 5th ed. (New York: John Wiley and Sons, Inc., 1984), p. 35.

Presently, cartography uses information collected from satellite systems. This information is transferred to computers for storage, compilation, analysis, and output. The most recent development in mapping terrain is called digital terrain modeling.<sup>41</sup> The computer is used to produce refined and accurate perspective images which appear three dimensional, as if viewed at an angle from above. Resources, land uses, rivers, roads, and any other sort of thematic information can be mapped on the surface, giving the map reader a view of the topography as it really is. The image can be tilted and rotated at will to provide new vantage points or to reveal information previously hidden by hills or other obstructions. The creation of Geographic Information Systems (GIS) is starting to revolutionize the way cartographers and non-cartographers think about maps and map making. A GIS is a system of computer programs which allow the user to encode either base data or thematic data digitally, along with alpha information such as labels or thematic attributes. This information can then be recalled on a graphic screen for viewing or can be reproduced on a plotter. The concept of making a map is still the same, but the way one goes about it and the amount of time required to complete maps is rapidly changing and will continue to do so.

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<sup>41</sup>Mark Monmonier and George A. Schnell, Map Appreciation. (Englewood Cliffs, New Jersey: Prentice Hall, 1988), p.396.

To summarize the discussion in this chapter, terrain mapping has evolved through the use of symbols. The first terrain symbols were simple lines that looked like fish scales. These were found on the Mesopotamian clay tablet (Figure 4). Ptolemy used a symbol which looked like a sugar loaf or mole hill to depict mountain ranges. This style of symbol was seen on maps up through the eighteenth century. About this time, the Romans were showing terrain with shaded relief as can be seen in the Peutinger table (Figure 6). Maps from Arabic culture of this time also use loafs to depict mountain terrain. During the time of the Renaissance, different forms of artistic rendering came to be used to portray relief. Around the eighteenth century, terrain mapping was enhanced with the advent of hachuring. Contour mapping developed in the nineteenth century. This affected terrain mapping greatly since it allowed for more precise measurement of terrain features on the map. At this time, the art of terrain mapping had progressed far enough that change was eminent. Developments that had taken place to this point had set the stage for new forms of terrain mapping such as field sketches, block diagrams, and physiographic diagramming.

### **Chapter 3**

#### **Development of Physiographic Diagramming**

##### **Field Sketches and Block Diagrams**

Field sketches and block diagrams are both cartographic methods used for displaying terrain which evolved soon after the development of hachuring and contour mapping.<sup>42</sup> They have been excluded from the preceding narrative because the author's research has revealed considerable evidence that these two art forms were the immediate ancestors to physiographic diagramming, as such, they require special attention at this point.

Of the two, field sketching developed first. Its roots can be traced back to landscape painting which emerged during the Renaissance. It grew into a specialized technique for depicting terrain features at the hands of the artists and scientists who accompanied expeditions during the period of great explorations. Block diagramming emerged later--at the turn of the twentieth century. The responsible party was a group of American geologists who were frustrated at the inability of field sketches to show the land's surface more

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<sup>42</sup>Field sketches and block diagrams have been defined and example illustrations have been displayed in Chapter One, pp. 5 and 6.

completely and to relate that surface to the underlying geologic structure.

### **The Development of Field Sketches**

It is hard to say when field sketches began to be used because of their relationship to landscape art. The roots of landscape painting can be traced back to the Renaissance in Europe. Most early landscape paintings existed as backdrops to some central figure or subject on the canvas--a person, a building, an animal, or some other object. By the beginning of the seventeenth century, landscape painting became an established art form, particularly in the hands of such European artists as Claude Lorrain and Nicholas Poussin of France, Jacob van Ruysdael and Meindert Hobbema of Holland, Antonio Canaletto and Francesco Guardi of Italy, and Joseph Mallord William Turner and John Constable of England.<sup>43</sup> It was not until the nineteenth century, however, that landscape painting became popular, largely as a result of the Romantic school in France, particularly the Barbizon group which produced artists with well-known names such as Camille Corot, Theodore Rousseau, Jean-Francois Millet, and Charles-Francois Daubigny. These efforts led to the development of the French Impressionist School which dominated the scene into the

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<sup>43</sup>Encyclopedia Americana, International Edition, s.v. "Landscape Painting," by Frederick A. Sweet.



twentieth century. Claude Monet, Camille Pissaro, and Edgar Degas were the most notable members.<sup>44</sup>

When Abel Janszoon Tasman conducted his first voyage into the Indian and Pacific oceans for the Dutch East India Company between 1639 and 1642,<sup>45</sup> an artist named Issac Gilseman, who was knowledgeable in the "drawing of land,"<sup>46</sup> was made part of the crew. Gilseman's renderings were not actual landscape paintings, but simple line drawings of the land as seen from the sea. If Gilseman's drawings were not the first field sketches ever produced, they were among the earliest. During the later stages of the Age of Exploration, the need to systematically record observations became increasingly important. Indeed, it became fashionable to include one or two artists along with the botanists, natural historians, and astronomers who usually participated in each sojourn.

One of the jobs of the artist was to make sketches of the landscapes encountered. Captain James Cook took artists on each of his major expeditions into the Pacific.<sup>47</sup> Alexander

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<sup>44</sup>The preceding paragraph contains information from the following sources: Ibid; John W. Mollett. The Painters of the Barbizon (London: Sampson Low, Marston, Searle and Rivington, 1890), pp. 4-5; Marco Valsecchi. Landscape Paintings of the Nineteenth Century (Greenwich Connecticut: New York Graphic Society Ltd., 1969), p. 41.

<sup>45</sup>Andrew Sharp. The Voyages of Abel Janszoon Tasman (London: Oxford University Press, 1968), p. 3.

<sup>46</sup>Ibid., p. 29.

<sup>47</sup>Alistair Maclean. Captain Cook (New York: Doubleday and Company, Inc., 1972), pp. 37, 107-108, 156-157.

Buchan, a landscape artist, and Sydney Parkinson, an artist who was to make pictorial recordings of all the fauna they caught, attended Cook on his first voyage between 1768 and 1771. Buchan later died in Tahiti of epilepsy; Parkinson died enroute between Batavia and the Cape of Good Hope. William Hodges, another landscape painter, and George Forester, a natural history draftsman, sailed with Cook on his second voyage. John Webber was the official artist on the third. Webber's painting of the "Death Scene" which depicts Cook's death at the hands of natives in Hawaii is one of the most often reproduced historical paintings in existence. Captain Cook, himself, occasionally drew field sketches of high quality when his artists were not along to do the job.

During the early exploration of the United States, the army created a branch known as the Topographical Engineers which operated from about 1838 to the time of the Civil War.<sup>48</sup> The Topographical Engineers were trained scientists, botanists, surveyors, and engineers commissioned with the intent of organizing and systematizing this most important period of exploration. The survey parties almost always included artists to portray the native cultures, the fauna and flora, and the landscapes encountered so others could "see" the unknown West. The artists included such individuals as Samuel Seymour who attended the Stephan Long expedition in

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<sup>48</sup>William H. Goatzmann. Army Exploration in the American West (New Haven: Yale University Press, 1959), p. 4.

1819-1820, R. H. Kern who went with the James H. Simpson expedition, and John Mix Stanley who traveled with the Issac Stevens survey party in 1857. E. W. Von Egloffstein and H. B. Mollhauser were members of the Pacific Railroad survey, and Thomas Moran and W. H. Holmes attended the F. V. Hayden survey.

During the time of the western surveys, a change began to take place in the appearance of landscape sketches. As the expeditions started being staffed with more educated and scientifically oriented people, such as the topographical engineers, landscape sketches began to appear at smaller scale. They not only covered more area, but began to use symbols to represent landforms and other features. Such sketches marked a major departure from those which had been produced earlier because they displayed landscapes which could no longer be viewed from one vantage point. Thus, they were more schematic and symbolic than their predecessors. Larger scale sketches were also drawn during this period, but even these had a more scientific bent, showing not only the surface features but also cross sections of the underlying geology--pointing in the direction of block diagramming.

From the time they first appeared during the Renaissance until the end of the nineteenth century, landscape sketches evolved from background paintings to functional sketches used to identify features and to transmit knowledge regarding geologic, botanical, cultural, and geographic facts about real

places. As symbolism in field sketches became more technical, it also became more systematized. By the turn of the twentieth century, the need was being felt for even more advanced methods of terrain representation.

### **The Inception and Development of Block Diagraming**

Although no explicit statement to the effect exists in the literature, there appears to be a progression from field sketches to block diagrams and then to physiographic diagrams. This notion is supported primarily by developments within the discipline of geology during the nineteenth century. During this period, geologists made extensive use of field sketches to illustrate different types of landforms. Although field sketches did allow surface areas to be displayed at least partially, they were restrictive because of the frontal views that were almost always employed. Moreover, field sketches did not provide a convenient means for the geologist to show underlying geological structure in relationship to surface landforms.

One of the methods devised to overcome at least some of the deficiencies of field sketches was to create geological cross sections. A geological cross section is a vertical map of the geological formations found beneath the surface of the earth. If the earth were sliced open, one side of the chasm would appear as a cross section. Done accurately, the top of the cross section forms a profile of the surface of the

earth. The similarity to field sketches is obvious--the uppermost line in either case forms a profile of the earth's surface. The cross section completed another step in the development of block diagrams; the only missing ingredient was perspective drawing.

Perspective is the science and art of representing on a plane surface the three dimensional appearance of objects according to established optical and mathematical principles. Whether used by artists to produce drawings, by architects to draw buildings, or by scientists to produce images of solid objects, the method is the same. Two items are necessary at the outset: a ground plan (or a map) of the object and elevations of the surface of the object above the ground. The perspective view is created by plotting this information relative to a horizon line and one or more vanishing points. Parallel perspective (or one-point perspective) is produced when only one vanishing point is used. Angular perspective (two-point perspective) employs two vanishing points and oblique perspective (three-point perspective) uses three.

Perspective drawing was first seen in the frescoes at Pompeii, although admittedly these first attempts were not entirely successful. Paolo Ucello (1397-1475), a Florentine realistic painter, was actually the first to solve the problem of linear perspective.<sup>49</sup> He employed it successfully in his

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<sup>49</sup>Encyclopedia Americana, International Edition, s.v. History of Perspective.

fresco, "The Flood," which is located in the church of saint Maria Novella in Florence. With this breakthrough, many Renaissance artists began to work with perspective, all of whom were interested in "representational correctness." In other words, their artwork was intended to represent reality.<sup>50</sup> Filippo Brunelleschi developed a mathematical process whereby a "cross section through the visual pyramid or cone" was utilized to produce perspective. Leo Battista Degli Alberti continued with this work and wrote a book on the subject.<sup>51</sup> At this point, the Dutch and Flemish schools of painting introduced aerial perspective into their work. This type of perspective allowed objects to be viewed as they would be seen at an oblique angle from above. Artists such as Van de Hayden, Hobbema, and Rembrandt used this technique, as did several Italian, Spanish, English, and French artists. Nineteenth century artists who used aerial perspective included Jean Baptiste, Camille Corot, Charles Francois Daubigny, Anton Mauve, Jozef Israels, Jacob Maris, and Claude Monet. One of the first methods used to produce aerial perspective was to copy contours as they appear on a glass plate and then trace them onto a panel. A frame with a grid could also be used. Neither method is very exacting.

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<sup>50</sup>Erwin Panofsky. The Codex Huygens and Leonardo Da Vinci's Art Theory (Westport, Connecticut: Greenwood Press Publishers, 1971), p. 91.

<sup>51</sup>William M. Ivans Jr. Art and Geometry (Cambridge: Harvard University Press, 1946), pp. 77-78.

Although artists had used the principles of perspective to represent landscapes in paintings for generations, the technique was not used by scientists to diagram blocks of the earth's crust until the idea was introduced late in the nineteenth century. Grove Karl Gilbert, an American geologist, is believed to be the first individual to publish a block diagram.<sup>52</sup>

The step taken to invent the block diagram was not a large one. Geologists had already been using field sketches in their work for many years so the concept of drawing landscape views was understood. Geologic cross sections and profiles had also been employed for quite some time. A block diagram is nothing more than a relatively precise field sketch drawn onto a block which has been laid out as an aerial perspective diagram with geologic cross sections constructed on the exposed sides (Figure 2, p. 5).

The techniques involved in producing a perspective block diagram are virtually identical to those that might be used by an architect to make a perspective drawing of a building. This can be seen by comparing Figures 14 and 15 on the

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<sup>52</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co. Inc., 1938) p. 21. Although Raisz indicates that Gilbert was the first to produce the block diagram, Stephen J. Pyne states that "he, Gilbert, didn't invent the block diagram". Although there is an undeniable discrepancy between these two sources the author found no evidence of an earlier inventor. The quote can be found in: Stephen J. Pyne, Grove Karl Gilbert a Great Engine of Research, (Austin and London: University of Texas Press, 1980), p. 90.

following pages. For a building, a floor plan must be drawn; then one or more vanishing points must be chosen and used to draft the base of the building to perspective. From this base, the heights of the walls are plotted along with the roof line. The details of the building are drawn onto that framework. For a block diagram, a base map must be prepared and a vanishing point selected from which a block is drawn. Within this block, the elevations of selected land features are plotted. These are used to position a sketch of the landscape on the surface of the block. The sides of the block can be used to display the underlying geologic structure in cross section.

Although it may be unclear whether Grove Karl Gilbert actually invented the block diagram, he is noted as one of several Americans, including William Morris Davis and Douglas W. Johnson, who were responsible for the refinement of the idea.<sup>53</sup> Gilbert (1843-1918) was a well-known and respected geologist who made his career with the United States Geographic and Geologic Survey under the direction of John Wesley Powell. He accompanied many of the survey teams sent into the western United States to assess resources and make maps during the last quarter of the nineteenth century. He was very good at making field sketches, many of which were used to illustrate his own publications and the official reports which

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<sup>53</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co. Inc., 1938), p. 291.



Stages in the preparation of block diagrams, drawn in one-point perspective.

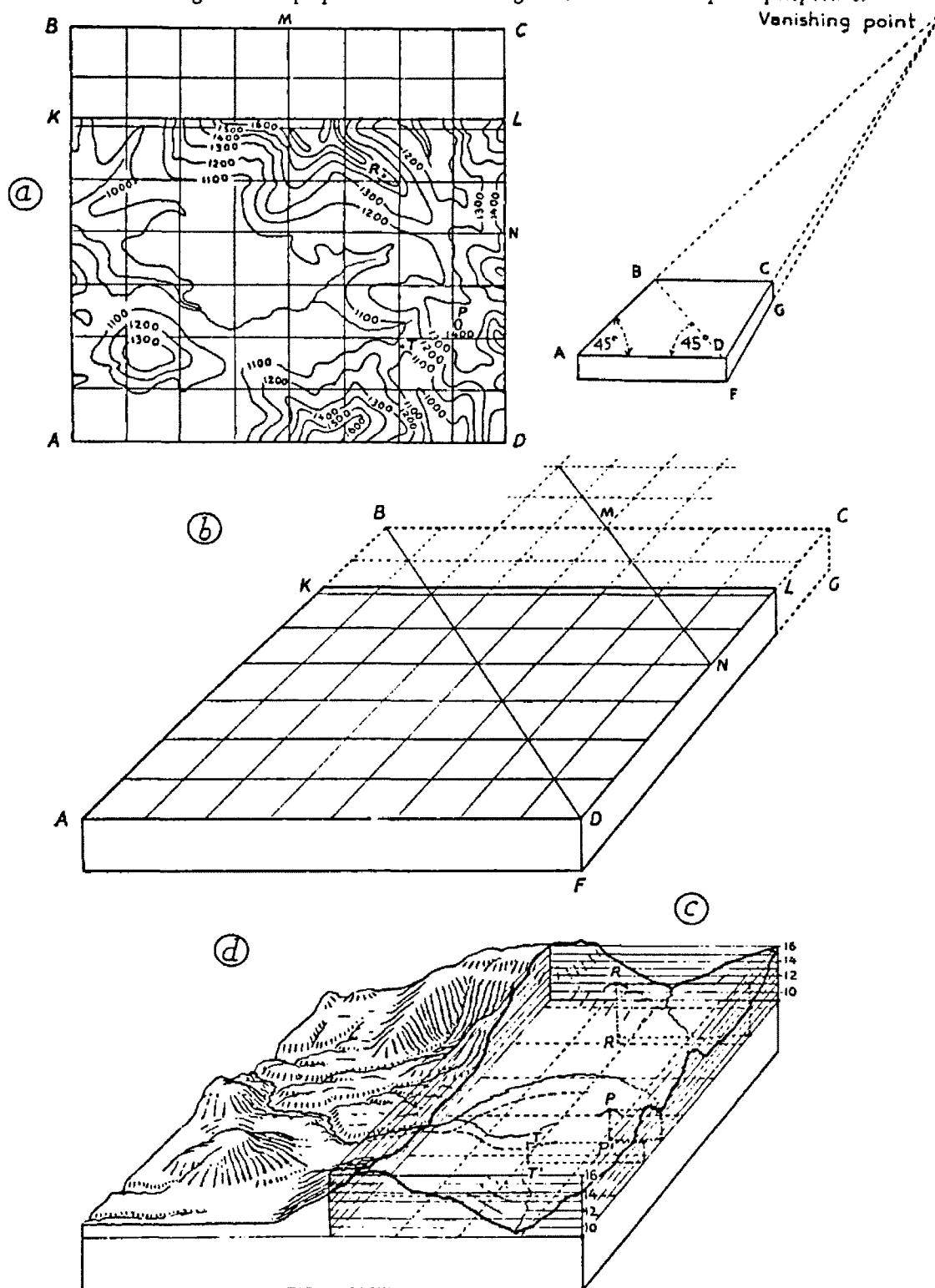


Figure 14 Block Diagram One Point Perspective<sup>54</sup>

<sup>54</sup>Erwin Raisz, Principles of Cartography (New York and London: McGraw-Hill Book Co. Inc., 1962) p. 226.

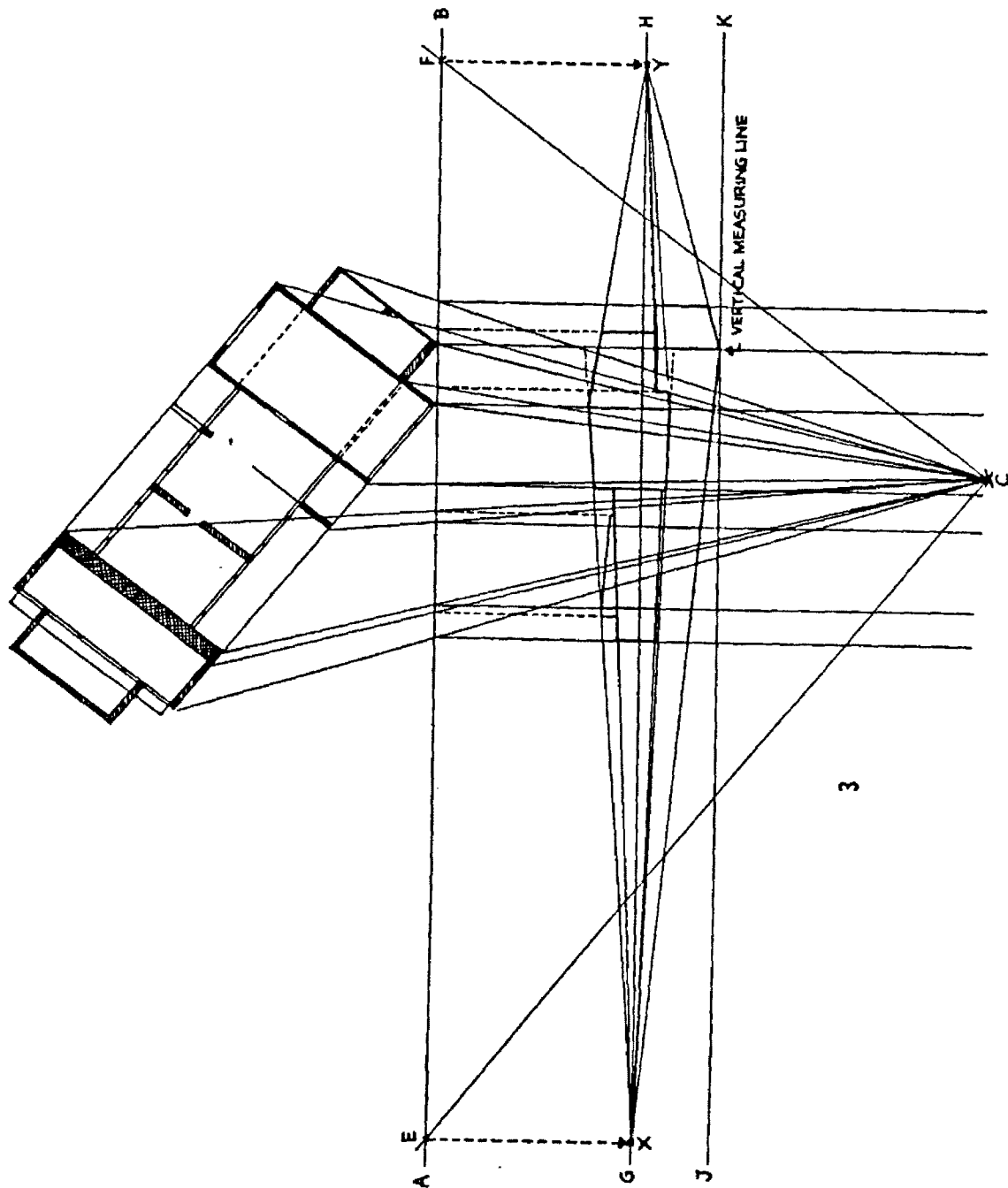


Figure 15 Architectural Drawing Two Point Perspective<sup>55</sup>

<sup>55</sup>Walter Brooks, The Art of Perspective Drawing (New York: M. Grumbacher, Inc., 1968), p. 19.

illustrate his own publications and the official reports which he helped produce. His work, Report on the Geology of the Henry Mountains,<sup>56</sup> contains many beautiful pen and ink sketches or landscape drawings and a block diagram, perhaps the first (Figure 16).

Although Gilbert received a degree in geology from the University of Rochester in 1862, he only taught there for one year.<sup>57</sup> It is doubtful that he trained many students in the art of block diagramming during that time. Consequently, it may be inferred that his methods of construction were passed along to other scientists only as a result of their having been observed in his publications.

William Morris Davis (1850-1934) was responsible for formalizing the concept of the block diagram. He not only drafted many high quality field sketches and block diagrams during his career but it is also very likely that he introduced the principles of their construction into the classroom.

Davis graduated from Harvard University in 1869, and received a Master of Engineering degree in 1870, also from Harvard. After working as a meteorological assistant for three years in Argentina, he returned to Harvard as the assistant to one of the geology professors. He remained in

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<sup>56</sup>Grove Karl Gilbert, Report on the Geology of the Henry Mountains Department of the Interior, U.S.G.S., John Wesley Powell in charge, 1877-1880.

<sup>57</sup>Richard A. Bartlett, Great Surveys of the American West (Norman: University of Oklahoma Press, 1962), p. 314.

that position and continued in his studies until 1885 when he became assistant professor of physical geography. He advanced in his career to become a full professor and ultimately the Sturgis Hooper Professor of Geology, a highly prestigious position at that university. He retired from Harvard in 1912. Professor Davis traveled widely; he taught as a visiting scholar in many universities, both in the United States and in Europe; and he researched and published continuously.<sup>58</sup>

Most of Davis's publications contained his own hand-drafted illustrations, among which were numerous block diagrams. The quality of his work drew this response from one of his biographers: "Illustration was perfected by him to a degree attained by no other single worker in the field."<sup>59</sup>His illustrations included field sketches, cross sections, hachure maps, and block diagrams, but no physiographic diagrams. An example of one of his block diagrams appears in Figure 17 (p. 60).

Evidence that Davis taught block diagramming in the classroom is manifested in the writings and professional activities of his students. In Particular, Douglas W. Johnson, who graduated from Harvard and went on to teach geology at Columbia University, was instrumental in continuing

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<sup>58</sup>Kirk Bryan, "William Morris Davis-Leader in Geomorphology and Geography," Annals of the Association of American Geographers 25 #1 (March 1935): 23-31.

<sup>59</sup>Ibid., p. 25.

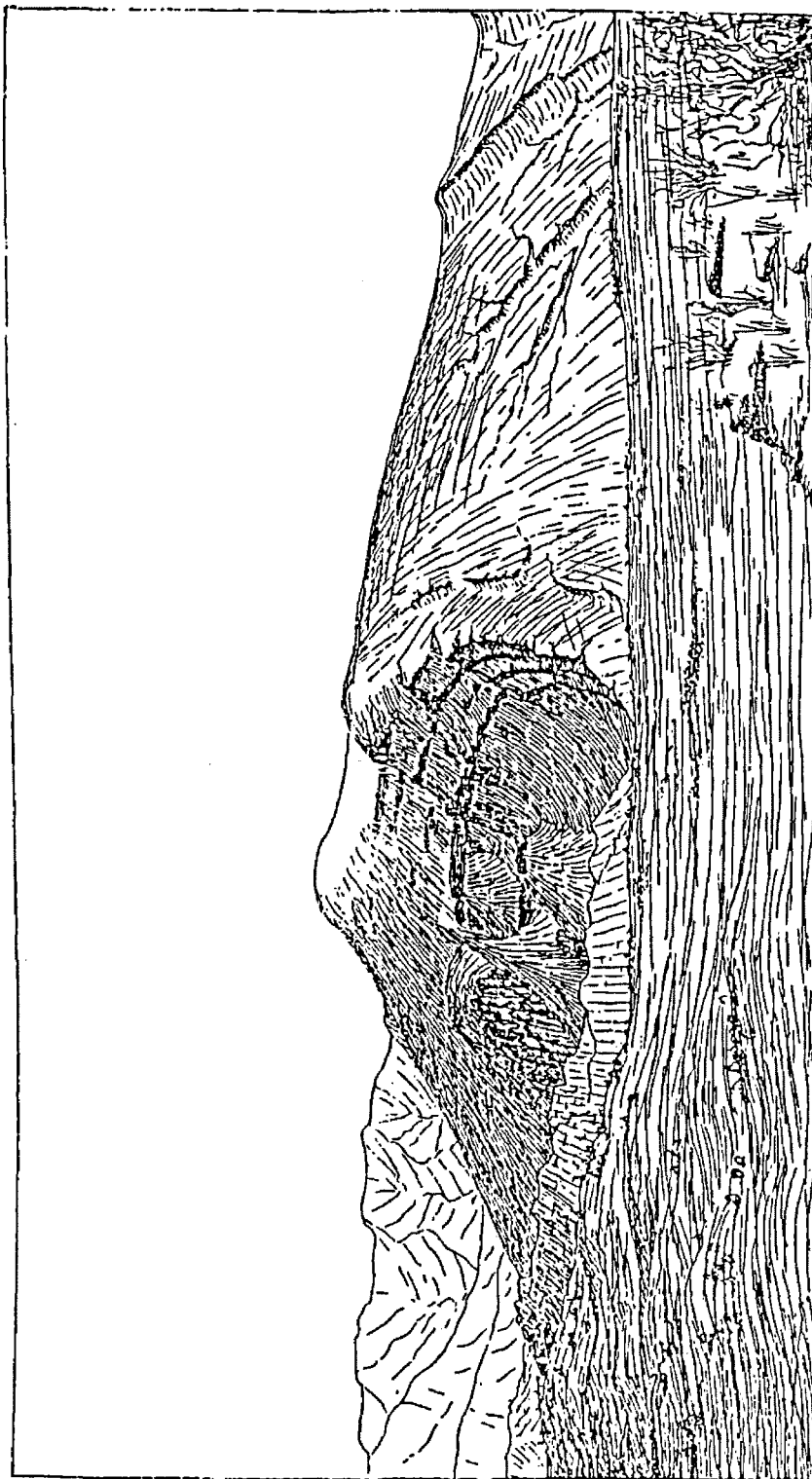


Figure 16 Gilbert Diagram<sup>60</sup>

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<sup>60</sup>Grove Karl Gilbert, Report on the Geology of the Henry Mountains, (Department of Interior, United States Geologic Survey, Rocky Mountain Division, John Wesley Powell in charge,

to teach field sketching and block diagramming. Johnson also illustrated his research with block diagrams. Two of his works provide outstanding examples of the status of block diagramming in the first decades of the twentieth century. The first, a book entitled The New England Acadian Shoreline,<sup>61</sup> used many high quality block diagrams as well as field sketches. The second publication is of particular interest regarding the development of physiographic diagramming because of the technique employed. This work, entitled The Battlefields of the World War<sup>62</sup>, contained several large-scale, block diagrams. However, because the information was not essential to the topic, the sides of the diagrams which would ordinarily contain the geologic cross sections were not included. As a result, Johnson's battlefield drawings bear remarkable resemblances to physiographic diagrams. Although it would be incorrect to refer to these illustrations as physiographic diagrams, certainly they may be viewed as being transitional in nature. This inference gains strength when one discovers that the person attributed with the invention of the physiographic diagram was one of Johnson's students. It gains even more strength when one learns that most of the

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1877-1880), p.40.

<sup>61</sup>D. W. Johnson, The New England Acadian Shoreline-Studies of American Physiography (New York: John Wiley and Sons Inc., 1925).

<sup>62</sup>Douglas Wilson Johnson, Battlefields of the World War (New York: Oxford University Press, 1921).

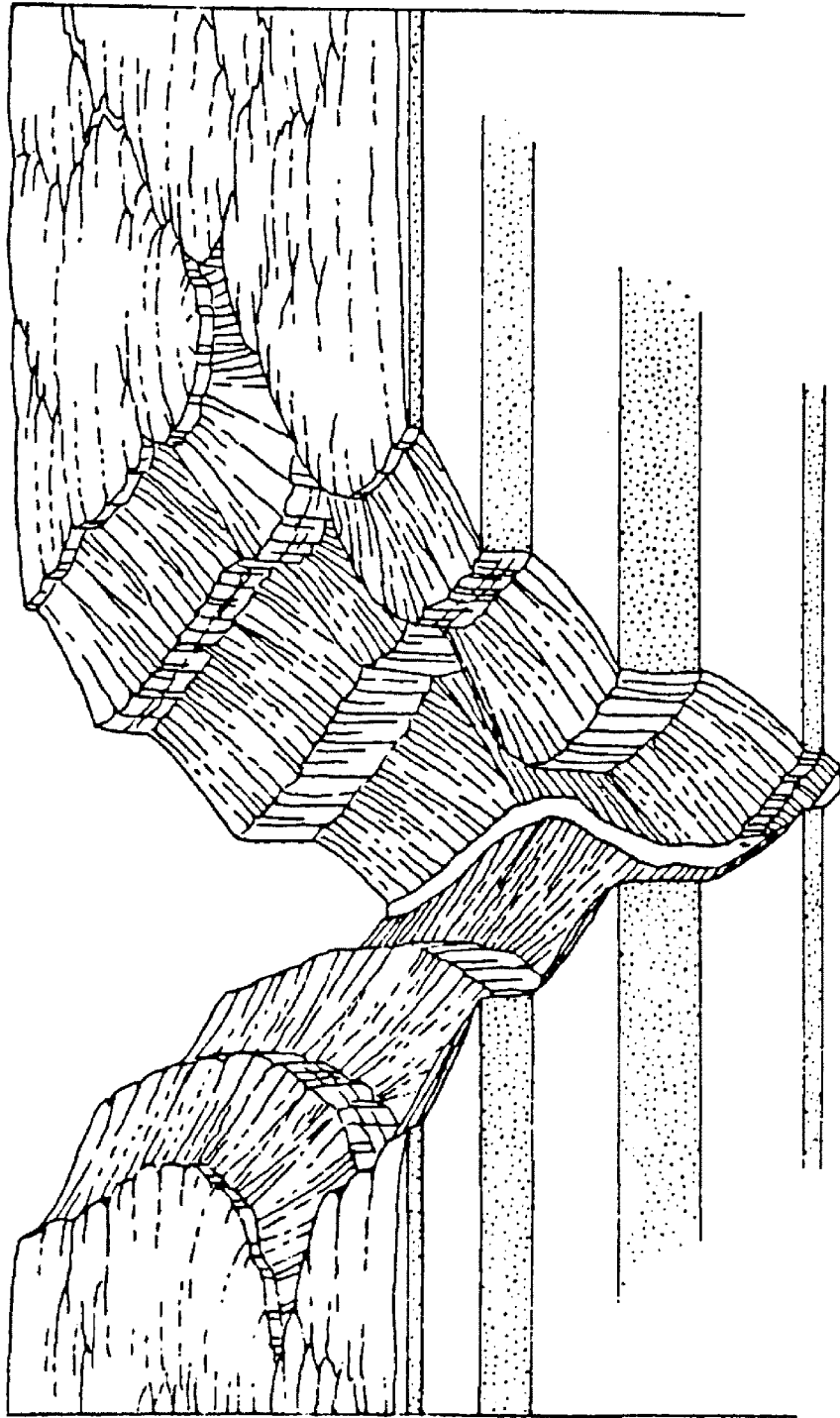


Figure 17 Davis Diagram<sup>63</sup>

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<sup>63</sup>Philip B. King and Stanley A. Schumm, The Physical Geography of William Morris Davis (Geo Books), p. 66.

diagrams in the book were actually drafted by three of his students, Armin K. Lobeck, Samuel H. Knight, and Fredrick K. Morris.

After graduation, Morris went to China to teach and conduct research; he is not known to have contributed further to the art of terrain illustration. Knight accepted a professorship at the University of Wyoming where he gained a remarkable local reputation for producing field sketches, block diagrams, and ultimately, physiographic diagrams. Representative of his work are the murals in the Geology Museum at the University of Wyoming which depict geological time periods for various landscapes throughout the state. Armin K. Lobeck became a geomorphologist with an international reputation. He is attributed with having invented the art of physiographic diagramming.

### **Development of the Physiographic Diagram**

Three people were paramountly important in the development of physiographic diagramming: Armin K. Lobeck, Erwin J. Raisz, and Guy-Harold Smith. As noted above, Lobeck is attributed with inventing the technique; he also published numerous high quality physiographic diagrams. Raisz did the most to systematize and develop the symbols used to produce the diagrams; he elevated the technical aspects of the art to a level attained by no other cartographer either before or since. Smith produced many elegant, yet simplified diagrams



which have tended to set the style for most of the physiographic mapping which has been done since the 1950's.

Numerous other individuals have made physiographic diagrams, including Bruce C. Heezen, James A. Bier, Wallace W. Atwood, Merril K. Ridd, Robert G. Janke, L.R. Goodman, Loyal Durand Jr., Philip B. King, Edith M. McKee, and Anna C. Coulton, to mention only some of those whose work was discovered during the research for this paper. While their diagrams have added substantially to the body of work done, few, if any, contain new ideas or techniques which have altered the way the diagrams are made. Consequently, the following paragraphs focus on the contributions of Lobeck, Raisz, and Smith.

While discussing physiographic diagramming in his textbook, General Cartography, Erwin Raisz wrote: "The first major map of this kind was A. K. Lobeck's Physiographic diagram of the United States (1921)."<sup>64</sup> Preston James, a well-known professor of geography and co-author of American Geography Inventory and Prospect, had this to say regarding the invention of physiographic diagramming: "The variously tilted landform map or physiographic diagram is possibly the only type of map that can be claimed as a wholly original contribu-

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<sup>64</sup>Erwin J. Raisz, General Cartography (New York and London: McGraw-Hill Book Co. Inc., 1938) p. 149.

tion of American geographic cartography."<sup>65</sup> He went on to observe:

. . . The landform map resulted from the work of William Morris Davis and others who in this century developed the mapping of block diagrams and perspective views of terrain into a high art. Although maps of this kind were prepared earlier those of A. K. Lobeck were the first major contributions.<sup>66</sup>

Several conclusions may be drawn from the preceding quotes. First, Armin K. Lobeck is attributed with inventing the art of physiographic diagramming. Second, he was able to do so only as the result of earlier work done by William Morris Davis and others in the areas of block diagramming and field sketching. Third, while it is no longer true that it is the only type of map that can be claimed as a wholly original contribution of American cartography, nevertheless it may be inferred that physiographic diagramming is exclusively an American invention.<sup>67</sup>

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<sup>65</sup>Preston E. James and Clarence F. Jones, American Geography Inventory and Prospect. (Syracuse: University Press, Association of American Geographers, 1954), p. 556.

<sup>66</sup>Ibid., p. 556.

<sup>67</sup>Since Preston James co-authored American Geography Inventory and Prospect, Americans have added significantly to new mapping methods particularly in the areas of computer mapping, satellite imagery, and remote sensing. One new type of map that comes to mind as being an American contribution is the so-called digital map. This type of map does not exist on paper, rather it resides in the computer as a data base. It is a fundamental component of the guidance systems for the cruise missile and other "smart" weapons currently being utilized by America's armed forces.

Armin K. Lobeck (1886-1958) was initially schooled in botany and architecture. He received his A.B. degree from Columbia University in 1911 and began teaching botany at the Philadelphia College of Pharmacy where he taught for three years. During this time, he also worked on and completed a Master's degree from Columbia in 1913. After concluding his teaching service in 1914, Lobeck returned to Columbia University to continue his graduate work, this time in physiography and geology under the direction of Douglas W. Johnson. Lobeck received his Ph.D. in 1917. It was through his association with Johnson that Lobeck became interested in illustrating landforms. Years later when writing about Lobeck's career, Guy-Harold Smith made this observation:

It was in the study of geomorphology and structural geology that he began to apply his knowledge of architecture to the representation of landforms, a method that became known as physiographic diagramming.<sup>68</sup>

Although the exact sequence of events was never recorded, they can be at least partially reconstructed through inference. One known fact is that Lobeck and two other students at Columbia University, Samuel H. Knight and Fredrick K. Morris, assisted Johnson in preparing the diagrams for a book entitled, Battlefields of the World War. While the diagrams in this book are technically block diagrams with their cross-sectional sides omitted, their appearance bears striking

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<sup>68</sup>Guy-Harold Smith, "Armin Kohl Lobeck, Geomorphologist and Landscape Artist, 1886-1958," Annals of the Association of American Geographers 49#1 (March 1959): 83-87.

resemblance to physiographic diagrams. Another known fact is that within a year or two, during the latter part of World War I, Lobeck took a position with the Department of State. There his job was to prepare physiographic diagrams of potential theaters of war including the Balkans, the Istrian Peninsula, Albania, and so on. The obvious inference is that someone at the State Department saw the diagrams in Battlefields of the World War, and Lobeck was hired to produce more diagrams of the same sort. In the process, and likely in his haste to prepare the diagrams quickly (block diagrams are more exacting to produce than physiographic diagrams), Lobeck probably made the simple transition from drafting block diagrams to producing physiographic diagrams. In this way the art of physiographic diagramming probably came into being.

When World War I ended, Lobeck became a member of the Geography Section of the American Commission to Negotiate Peace and went to the Paris Peace Conference in December of 1918. It was here that Lobeck met Professor C. K. Leith, Chairman of the Geology Department at the University of Wisconsin. Lobeck was offered a job as physiographer-geographer, a position which he retained for three years. While there he started the Wisconsin Geographical Press.<sup>69</sup> In 1929 Lobeck returned to Columbia University as Professor of

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<sup>69</sup>This business was owned by Lobeck; he renamed it The Geographical Press and after his retirement in 1954, transferred the press to C.S. Hammond and Co. Lobeck started this business due to the lack of high quality printing facilities, and he desired superior output for his graphic productions.

Geology; he remained in that position until his retirement in 1954.<sup>70</sup>

In addition to those appearing in books and journals, Lobeck produced a series of physiographic maps which were published individually. The first was a diagram of the United States published in 1921 drawn at a scale of one to three million. As noted earlier, this is the physiographic diagram Raisz believed to be the first ever produced. The date it was actually drawn is not known. One year later he drafted a smaller scale version of the United States which was also published. In this same year, the American Geographic Society published more of Lobeck's physiographic diagrams which he had drawn during 1918 and 1919. These included diagrams of Albania, the Balkans, the Lorraine, Trentino, and Trieste Isonzo which had originally been prepared for the Paris Peace Conference.

In 1923 Lobeck published a small-scale edition of a physiographic diagram of Europe which appeared in an eight page folio describing the geography of the region. This work set the pattern for several more physiographic diagrams which

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<sup>70</sup>During his career Lobeck produced many block diagrams, physiographic diagrams, and several books. The following is a list of his books which were examined for this study: A. K. Lobeck, Airways of America, Guide Book of American Airlines. (Columbia University: The Geographical Press, 1933); A. K. Lobeck, Things Maps Don't Tell Us (New York: MacMillian and Co. Inc., 1973); A. K. Lobeck, Block Diagrams and Other Graphic Methods used in Geology and Geography (Amherst: Emerson-Trussell Co., 1958); A. K. Lobeck, Geomorphology, (New York and London: McGraw-Hill Book Co. Inc., 1939).

were all produced in their individual folios. In 1944 a large-scale version of Europe was produced along with a folio. In 1945 a diagram and folio for Asia appeared; in 1946 Africa; in 1949 North America; and in 1951 Pennsylvania. Numerous copies of these folios were printed and sold as supplementary material for regional geography courses taught at the university level. In addition to the folios, Lobeck published an atlas entitled, An Atlas of American Geology<sup>71</sup> which included over 100 block diagrams, physiographic diagrams, and cross sections along with supporting text.

Lobeck's renderings tended to be technical, yet artistic; all were well drawn. Because of their large scale, his block diagrams were precise, the symbolism for the underlying geology informative. Lobeck never employed systematic sets of symbols to depict terrain in his physiographic diagrams. The features were sketched to look like mountains, plains, hills, and valleys. The terrain on Lobeck's physiographic diagrams was very similar to that on his block diagrams except it was produced at much smaller scale, and, of course, without an underlying block.

The second person intricately involved with the development of physiographic diagramming was Erwin J. Raisz (1893-1968). Raisz was born in Hungary; he attended the Royal Polytechnicum in Budapest where he received an engineering

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<sup>71</sup>A.K. Lobeck, Atlas of American Geology (Columbia University: The geographical Press, 1932 and 1960).

degree in 1914. During World War I he joined the Imperial Engineers. He remained with them for four years, after which he worked for five years in an architect's office in Budapest. In 1923 Raisz immigrated to the United States and went to work for the Oman Map Co. in New York City. While working there he attended graduate school at Columbia University where he received an M.A. in Geology in 1924. In 1927 he was invited to teach a course in cartography at Columbia while continuing to attend classes. In 1929 he received his Ph.D. in Geology. Coincidentally, at about this time, Lobeck had returned to Columbia to teach. It is quite probable that these two met there and may have shared ideas concerning mapping techniques. Unfortunately, there is no documentation of this.

While he was at Columbia University, Raisz was able to work with Douglas W. Johnson just as Lobeck had a few years previously. Through Johnson, Raisz became acquainted with William Morris Davis who was able to help him find a position at Harvard University with the Harvard Institute of Geographical Exploration.<sup>72</sup> Raisz remained with this organization for the next twenty years until the Institute closed. Raisz's career with the Harvard Institute of Geographical Exploration marked the most productive period of his life. Arthur H.

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<sup>72</sup>It is unclear whether Raisz actually knew Davis who by this time was quite old and probably not teaching. It is more likely that Johnson recommended Raisz to Davis who passed this on to the Harvard Institute of Geographical Exploration.

Robinson, another renowned cartographer, had this to say regarding this part of Raisz's career:

During that period he produced many hundreds of maps for a variety of publications, two atlases, the first and second editions of his General Cartography, scores of papers in professional journals, encyclopedia articles, and reviews.<sup>73</sup>

After the Harvard Institute of Geographical Exploration was closed in 1950, Raisz worked at home in his own cartographic lab producing maps and diagrams. During this period he also taught at universities in Virginia, Florida, British Columbia, and at Clark University. He enjoyed teaching but was softspoken and difficult to understand. Robinson had this to say regarding his strengths:

He shone a technologist, however, and delighted in working out new and better ways of handling cartographic problems. He devised new methods of symbolism (e.g. rectangular cartograms and block piles), new map projections (e.g. orthoapsical), organized physiographic representation systematically by treating it as a problem of symbolic categorization, and he was continually working on methods of adapting the air photograph and later other kinds of sensors, to the needs of cartographic representation.<sup>74</sup>

It is generally understood that Erwin Raisz was the main contributor to physiographic diagramming; no other single person did more to systematize the symbols either before or after him. Robinson continues:

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<sup>73</sup>Arthur H. Robinson, "Erwin Jospehus Raisz, 1893-1968," Annals of the Association of American Geographers 60 #1 (March 1970): 189.

<sup>74</sup>Ibid., p.191.



Building upon the graphics ideas of W. M. Davis, D. W. Johnson and A. K. Lobeck, Raisz aimed to make his landform maps explain the territory. Tremendously detailed they delineated the significant elements of the terrain in pictorial-diagrammatic fashion.<sup>75</sup>

Raisz's contribution to geography and to cartography is immense. Besides all of the publications he authored, he organized a cartography group within the Association of American Geography in 1945; he promoted the idea of a map supplement for the Annals of the Association of American Geographers and was the first map editor for that publication. He published widely in educational journals and promoted map use for school textbooks. He was honored by The National Council for Geographic Education in 1947; he received the Meritorious Achievement Award in 1955 and the Distinguished Service Medal of the Geographical Society of Chicago in 1959. Raisz served as cartographer and editor for publications issued by Modern School Supply Co. of Goshen Indiana, and he made many landform maps for the Environmental Protection Agency of the Office of the Quartermaster General of the U.S. Army.<sup>76</sup>

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<sup>75</sup>Ibid.

<sup>76</sup>Raisz's wife started the antique shop in Boston in their early years to help their relatives still living in Hungary. After Erwin's death she continued to sell his maps. She died in 1986 but the shop will continue to sell the "Raisz Maps." Erwin's affairs are now handled by his granddaughter out of Jamaica Bay. This information taken from a telephone conversation with the antique store manager while ordering a set of the maps.

As with Lobeck and Smith, Raisz's works are almost too numerous to list; however, he produced three sets of maps

Guy-Harold Smith (1895-1976), attended the University of Wisconsin at Madison as a student then taught there as a professor. He began teaching at the University of Ohio in 1934 as an associate professor, a year later he became the chairman of the Department of Geography at Ohio, a position he retained for 29 years before retiring in 1965.

Smith's contribution to physiographic diagramming does not involve the development of new techniques, but his skill and dedication to the art warrant his being included with Lobeck and Raisz as a major contributor.

It has been said that his physiographic drawings reveal not only a knowledge of surface features and the underlying geology on which they are based, but also an artistry of painstaking detail and infinite space.<sup>77</sup>

Indeed, Smith considered his physiographic diagram of Japan, Figure 18, to be his finest work although he also did the driftless hills of Iowa, Minnesota, Illinois, and Wisconsin. He was the cartographer for Fenneman's Physiography of the Western United States<sup>78</sup> and some of his drawings were

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which were published in Boston. Many of these maps are still available through his wife's antique shop for approximately \$18.00 for 30 or more maps.

<sup>77</sup>S. Earl Brown, "Guy-Harold Smith, 1895-1976," Annals of the Association of American Geographers 68 #1 (March 1978), p. 115.

<sup>78</sup>Nevin M. Fenneman, Physiography of the Western United States (New York and London: McGraw-Hill Book Co. Inc., 1931).

included in Lobeck's Airways of America.<sup>79</sup> Smith's style of physiographic diagramming was not as systematic as Raisz and perhaps not as exacting as Lobeck, but it was the most pleasing to the eye and the most easily read of all three. Smith wrote many journal articles and several books, and also created many maps. He is probably best known for his contribution to the book Conservation of Natural Resources<sup>80</sup>.

Physiographic diagramming is an American mapping form. It evolved from the early use of symbolic representation, through impressionist painting, perspective drawing, and field sketching to technical drawing and block diagramming. Overall there have been many contributors from differing places around the world and from different professions but the basic form and structure started in the United States early in this century with the contributions of Lobeck, Raisz, and Smith.

These three produced the most diagrams, and were most beneficial to the evolution of the art form. In particular, Raisz designed new symbols adding to and upgrading the form. The following chapter addresses these very topics in greater depth.

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<sup>79</sup>A. K. Lobeck, Airways of America (Columbia University: The Geographical Press, 1933).

<sup>80</sup>Guy-Harold Smith, Conservation of Natural Resources (New York: John Wiley and Sons, 1950).

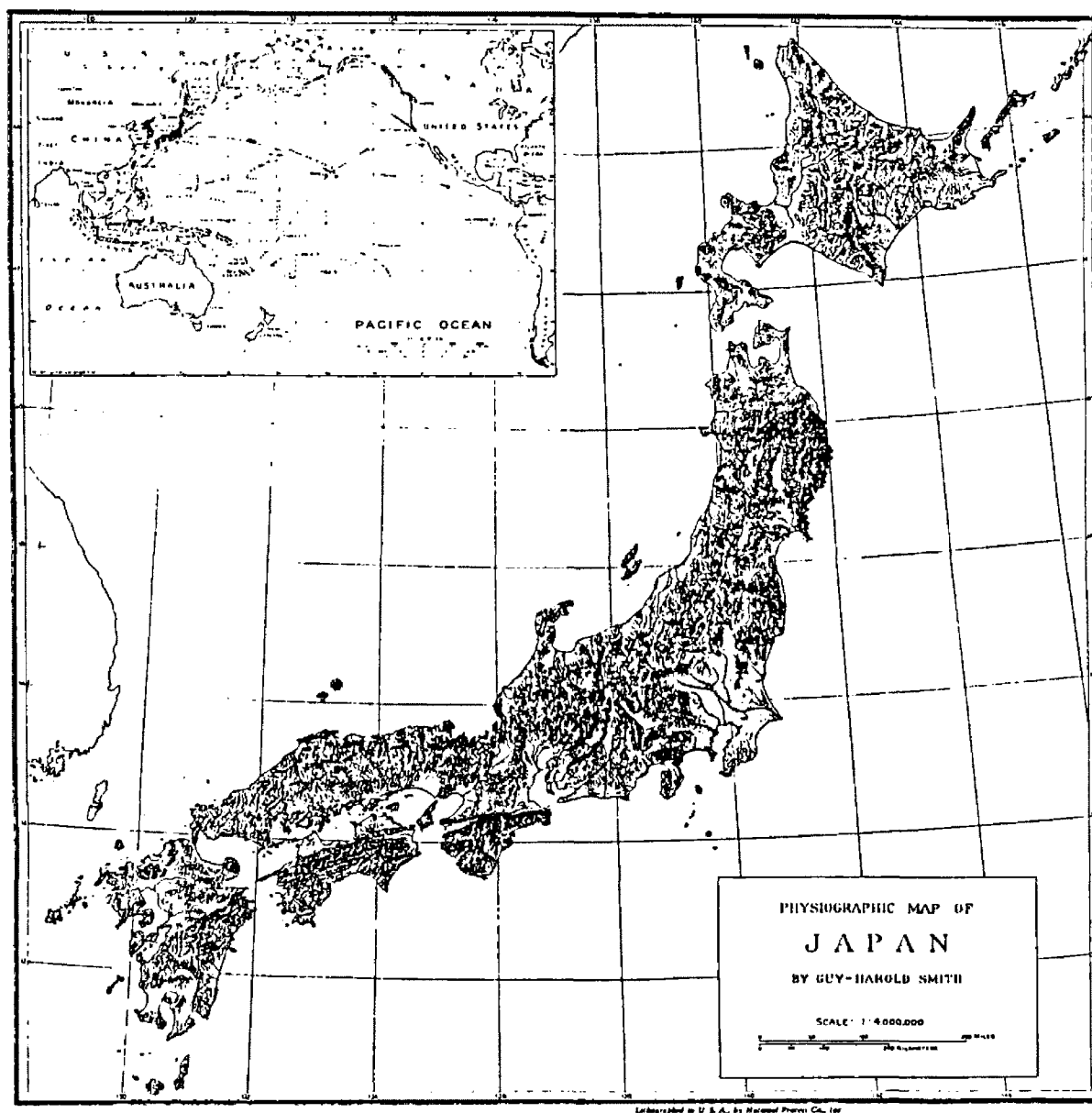


Figure 18 Guy-Harold Smith Physiographic Diagram.<sup>81</sup>

<sup>81</sup>Guy-Harold Smith and G.T. Trewortha, "Notes on a Physiographic Diagram of Japan," Geographical Review 24, 1934.

## **Chapter 4**

### **Data Acquisition and Analysis**

#### **Introduction**

One objective of this thesis is to comprehend the qualities of physiographic diagrams. What elements comprise them; do they employ standardized sets of symbols; what types of media are used for their creation; how do they relate to the landforms they represent? In order to answer these and other questions, 136 physiographic diagrams were viewed and carefully studied. Information about them was systematically gathered, cataloged, and analyzed.

In particular, the physiographic diagrams produced by Lobeck, Raisz, and Smith were selected as representative of all physiographic diagramming. These three men are the masters of the form; they also produced the most diagrams. As a consequence, their work was scrutinized most closely.

#### **Acquisition and Manipulation of Information: Library Search**

The survey information was collected from physiographic diagrams found at the following libraries: University

of Montana Mansfield Library, University of Wisconsin Historical Society Library Rare Book Collection, University of Wisconsin Memorial Library, University of Wisconsin A.G.S. Collection (Milwaukee), University of Wisconsin Geography Library, the University of Wisconsin Madison Robinson Map Library, and University of Wisconsin Geology Library.

### **Survey Form**

To learn about the development of physiographic diagramming, it was necessary to view many diagrams. It would be impossible to remember the similarities and differences between 136 maps, so this information had to be collected and stored in a systematic fashion. In order to accomplish this task, it became necessary to create a map survey form (Figure 19) to catalog the large amount of information in a systematic manner.

A systematic classification of symbols designed for the survey form was set up in an attempt to cover all symbols used. The comparisons for this set of symbols were taken from a master list produced by Erwin Raisz (Figure 20 pp. 86-90). His set does not include all of the physiographic symbols that exist, but certainly it includes the majority of them. It is by far the most systematic set of symbols gathered. It was necessary to keep this set of symbols on hand as a comparison chart

when viewing diagrams so that symbols appearing there could be classified, categorized, and catalogued. The general symbols used for cataloguing were: plains, plateau, mountains, lavaforms, limestone forms, desert features, glacial features, water, cultural, and other.

The survey sheet contained information about other variables as well as including who created the map, the location that the map represents, the date of authorship, and general impressions about the map. The scale, lettering, graticule, colors, notes, profession of the map author, call number, etc., while important information, were not as useful to this study. Nevertheless, this information was also gathered at the time the data were collected. It was deemed important to gather more information than would likely be used as many of these diagrams might not be available at a later date. Many of the maps could not be photocopied at the time due to library restrictions.

Most of the spaces on the form do not require explanation, such as Map Author, Profession, Date, and, Map Location. The remainder do:

Source--publisher.

Scale Vertical--the amount of vertical exaggeration present, a subjective measurement in proportion to other scaled items on the map.

Scale horizontal--linear scale, the ratio between a distance on map and the corresponding distance on the earth's surface, e.g. 1:24,000, one inch on the map represents 24,000 inches on the ground.

Library Call #

Date:

CATALOG OF PHYSIOGRAPHIC DIAGRAMS

Map Author:

Profession:

Date:

Map Location:

Source:

Map Description:

Scale: Vertical

Horizontal

Direction of Illumination:

Symbols: (New or Different)

R e a l i s m	Physical									
	Symbol Type									
	Never									
	Sometime									
	Always									
	Cultural									
	Symbol Type									
	Never									
	Sometime									
	Always									

Lettering:

	Upright	Italic	Serif	Sans Serif	Hand Lettering	Photo-Mechanical	Leroy
Legend							
Places							
Physical Features							

Graticule:

Color/Shade:

Impression:

Notes:

Figure 19 Survey form



Direction of Illumination--direction the lighting appeared to be coming from, decided by looking at the shadow in the landform, i.e. from the north-west, etc.

Symbols, New or Different--symbols which have not been seen before or symbols which are different when compared to symbols in the Raisz Tables.

Realism, Physical, and Cultural--a subjective view by the author as to how realistic the symbols are.

Graticule--a yes or no question as to whether or not the map utilized a coordinate system.

Color/Shade--the most predominant color used on the map.

Impression--place for notes of the impression of the map.

Although the form is just a page in length, it covers many aspects of the physiographic diagrams which were surveyed. The information compiled from the survey forms is discussed in the remaining parts of this chapter.

### **Coding the Survey Form**

In order to obtain easier access to all of the survey information, Dbase 3+<sup>82</sup> was used. This computer program allowed the input of all variables including date, numeric, and text information into records (survey type forms). Once all of the information had been entered, it could be sorted and extracted in any fashion desired. For example, if only information concerning mountain symbols

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<sup>82</sup>Dbase 3+ is a microcomputer data base management system. It is produced by the Ashton-Tate corporation.

was required, the program had the ability to retrieve only the data concerning mountains. The utility of this was in the ease with which each separate item on the survey could be retrieved for analysis without having to view everything or go through every field (single block of information within a record) to find a certain bit of information. In effect, this system took the place of hundreds of note cards for storage of information in this thesis.

### **Summaries, Analysis and Descriptions**

Table 2 ("Landform by Cartographer") shows the number of maps catalogued for each author. Although there were a total of 136 maps catalogued, those which showed no author were omitted from this table. The numbers appearing in the table also indicate the frequency with which the various physiographic symbols were used.

When looking at Table 2 it is clearly seen that progression of symbol use is in the following order; mountains (112), plains (91), plateau (90), desert (39), water (37), lavaform (34), glacial (23), limestone (12). While others appeared less often, these symbols were the most widely used of all of those catalogued. Of the twenty-five cartographers surveyed, fifteen used the plains symbol, thirteen used plateaus, twenty-two used mountains, five used lava formations, two used limestone formation, seven used desert and glacial, and nine used

Symbol	Plain	Plateau	Mountain	Lava Form	Limestone form	Desert	Glacial	Water	Total Maps
Map Author									
AGS	2	2	2	0	0	0	0	0	2
Alpha	1	1	1	1	0	1	0	1	2
Atwood	3	3	2	0	0	0	0	0	4
Batista	0	0	1	0	0	0	0	0	1
Bier	2	2	1	0	0	0	2	1	2
Durand	0	1	0	0	0	0	1	0	1
Goodman	2	2	1	0	0	2	1	1	2
Gulllaume	1	0	1	0	0	0	0	1	1
Gutierrez	0	0	1	0	0	0	0	0	1
Heezen	3	3	3	0	0	0	0	0	3
Jaillet	0	0	1	0	0	0	0	0	1
Janke	1	0	0	0	0	0	1	0	1
King	1	1	2	0	0	0	0	2	2
Lewis-Clark	0	0	1	0	0	0	0	0	1
Lobeck	13	9	11	3	0	3	0	4	14
MacFaden	2	4	5	0	0	3	1	0	5
Mckee	0	0	1	0	1	0	0	1	1
Mercator	0	0	2	0	0	0	0	0	2
Mitchell	0	0	0	0	0	0	0	0	0
Reisz	50	47	58	28	11	27	16	25	64
Ridd	1	1	1	1	0	1	0	0	1
Roman	0	0	1	0	0	0	0	0	1
Smith	9	14	14	1	0	2	1	1	15
Soulard	0	0	1	0	0	0	0	0	1
Todeschi	0	0	1	0	0	0	0	0	1
Total	91	90	112	34	12	39	23	37	119

Table 2 Landform by Cartographer

water. The mountain symbol was the most widely used with plains and plateau as second and third most significant.

The decision was made to look at authors having the most maps catalogued. This was done with the idea that cartographers who were producing the largest number of physiographic diagrams would probably have developed the most systematic set of symbols. When looking at the table, one can see that three of the cartographers stand out far above the rest. Erwin Raisz is best represented with a total of sixty-four maps. Guy-Harold Smith is represented by fifteen maps, Armin Lobeck by fourteen.

### Analysis

There is a set of basic symbols used by Lobeck, Raisz, and Smith. For example, all three used similar symbols for mountains, plains, plateaus, and deserts. Although these symbols may vary slightly, in all cases the diagrams viewed were rated at better than 75 percent realistic all of the time (Table 3).<sup>83</sup> This Table shows the percentage of realism for the three major authors of physiographic diagramming.

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<sup>83</sup>Realism is a subjective assessment, by the author, of the appearance of a map symbol. Percent of realism is based on the number of times a symbol was found to be "always" realistic divided by the total times that symbol was used on the survey form. For example Lobeck's plains look realistic 95% of the time.

AUTHOR	LOBECK	RAISZ	SMITH
SYMBOLS	%	%	%
Plains	95	89	86
Plateau	78	91	100
Mountain	91	99	100
Lava form	100	91	0
Limestone Form	0	57	0
Desert	100	71	100
Glacial	0	64	100
Water	100	89	0

Table 3 Symbol by Author

When the works of Lobeck, Raisz, and Smith were considered together, it was found that some symbols appeared more real than others. The diagrams of mountains and lava forms were rated realistic greater than 90 percent of the time, water greater than 88 percent, plains greater than 85 percent of the time, plateaus greater than 77 percent, desert greater than 70 percent, glacial greater than 63 percent and limestone form greater than 56 percent.

Lobeck's highest scores, for realism, are seen with his depiction of plains, lava forms, desert, and water. His plateau and mountain symbols are third in comparison with the others. Lobeck did not produce limestone form or glacial symbols. Raisz came in second in the depiction of all physiographic symbols, with the exception of limestone

formation; however, he was the only producer of that symbol. Raisz's production of the primary symbols--plains, plateau, and mountain--are between 89 to 99 percent realistic. Smith showed his best production with plateau, mountain, desert, and glacial features. His rendition of plains came out third. He made no attempt to depict lava forms, limestone forms, or water. Raisz seems to show the most consistent depiction of symbols and also he produced a greater variety of symbols.

In Table 4 total number of maps on which different symbols appeared is shown by author. With a quick glance, it is easily seen how many maps each author produced with varying types of symbols. The table can be used to show comparisons, for example who produced the most mountains.

### **Description of Variations**

While viewing various authors' works, it is very difficult to determine the ways in which a given symbol might vary, with the exception of Erwin Raisz's maps. While variations can be seen in Raisz's work over time, they amount to very little. Moreover, in the case of his work, even minor variations could be determined. This is due to the systematic list of physiographic symbols Raisz put together which he used as the standard for most of his work. When he deviated from this standard, it was easier

<b>Author</b>	<b>Raisz</b>	<b>Lobeck</b>	<b>Smith</b>	<b>Others</b>	<b><u>Total</u></b>
<b><u>Subject</u></b>					
Plain	50	13	9	19	91
Plateau	47	9	14	20	90
Mountain	58	11	14	29	112
Lavaform	28	3	1	2	38
Limestone	11	0	0	1	12
Desert	27	3	2	7	39
Glacial	16	0	1	6	23
<u>Water</u>	<u>25</u>	<u>4</u>	<u>1</u>	<u>7</u>	<u>37</u>
Scale	60	14	15	26	115
Grid	28	4	3	19	54
<b><u>Lettering</u></b>					
Hand	57	5	2	34	98
Leroy	2	0	11	8	23
Photo	0	4	0	0	4
<b><u>Color</u></b>					
Brown	15	0	0	1	16
Black	48	14	15	28	105
Blue	0	0	0	6	0

Table 4 Maps by Author (number per subject)

to see differences and have a basis for comparison. To see these symbols, it is best to look at Figure 20. Raisz did use many minor variations of each symbol, as he made maps of different parts of the world exhibiting specialized features.

Examples of symbol variations are shown in Figure 21, which shows all of the symbols which were copied into the new and different section of the survey form for the three authors. This Figure includes new symbols, which the author had not seen before, as well as symbols which differ from the standards provided by Raisz's Table. To notice a difference, these symbols should be compared to Raisz's Table, Figure 20. The symbolism used in depicting glaciers, drift areas, and plateaus seems to vary between authors and in the Raisz standards. Plains and mountain symbols are relatively standard and do not differ too much. Raisz did some fine tuning of the basic mountain symbol to depict block, folded reduced, complex or glaciated mountains. It could be said that Raisz did this with all of his symbols.

#### **Standards of Symbolism: Basis for Study of the Three Main Cartographers**

The author has found it necessary to use information collected from the most productive physiographic diagraphers found in the survey. This selection was accomplished by assessing the frequency with which their



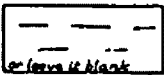
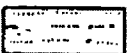
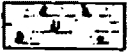
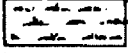
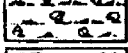
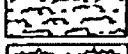
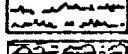









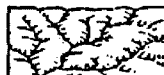
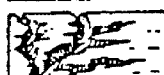
TABLE OF PHYSIOGRAPHIC SYMBOLS		
1. PLAINS	if no distinction is made	
a)	sand + gravel plain	
b)	semiarid	
c)	grassland	
d)	savannah	
e)	forest	
f)	needle forest	
g)	forest swamp	
h)	swamp	
i)	tidal marsh	
j)	cultivated land	
2.	Coastal plain (as Eastern N.J.)	
3.	Flood plain (Mississippi valley)	
4.	Alluvial fans, Conoplain (Southern California)	
5.	Cuesta land (Paris basin)	
6.	Plateau, maturely dissected, in humid regions (Allegheny Plateau)	
7.	Plateau, subdued, in humid regions (Eastern Ohio)	
8.	Plateau, young in arid regions. (Canyon land) (Grand Canyon)	

Figure 20 Raisz's Physiographic Symbols<sup>84</sup>

<sup>84</sup>Source: Erwin Raisz, General Cartography (McGraw-Hill Book Co. 1938):151-153.

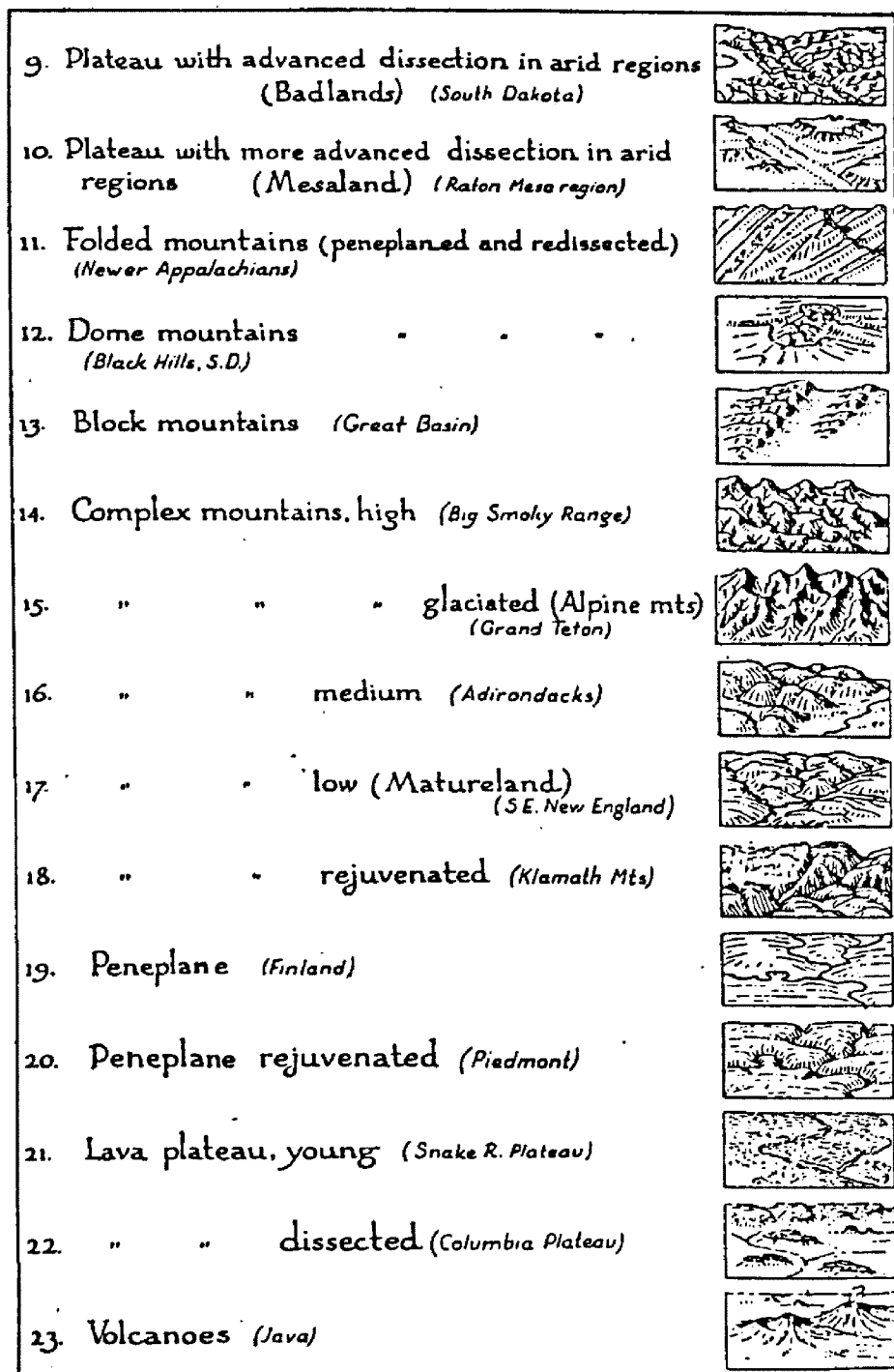


Figure 20 Raisz's Physiographic Symbols

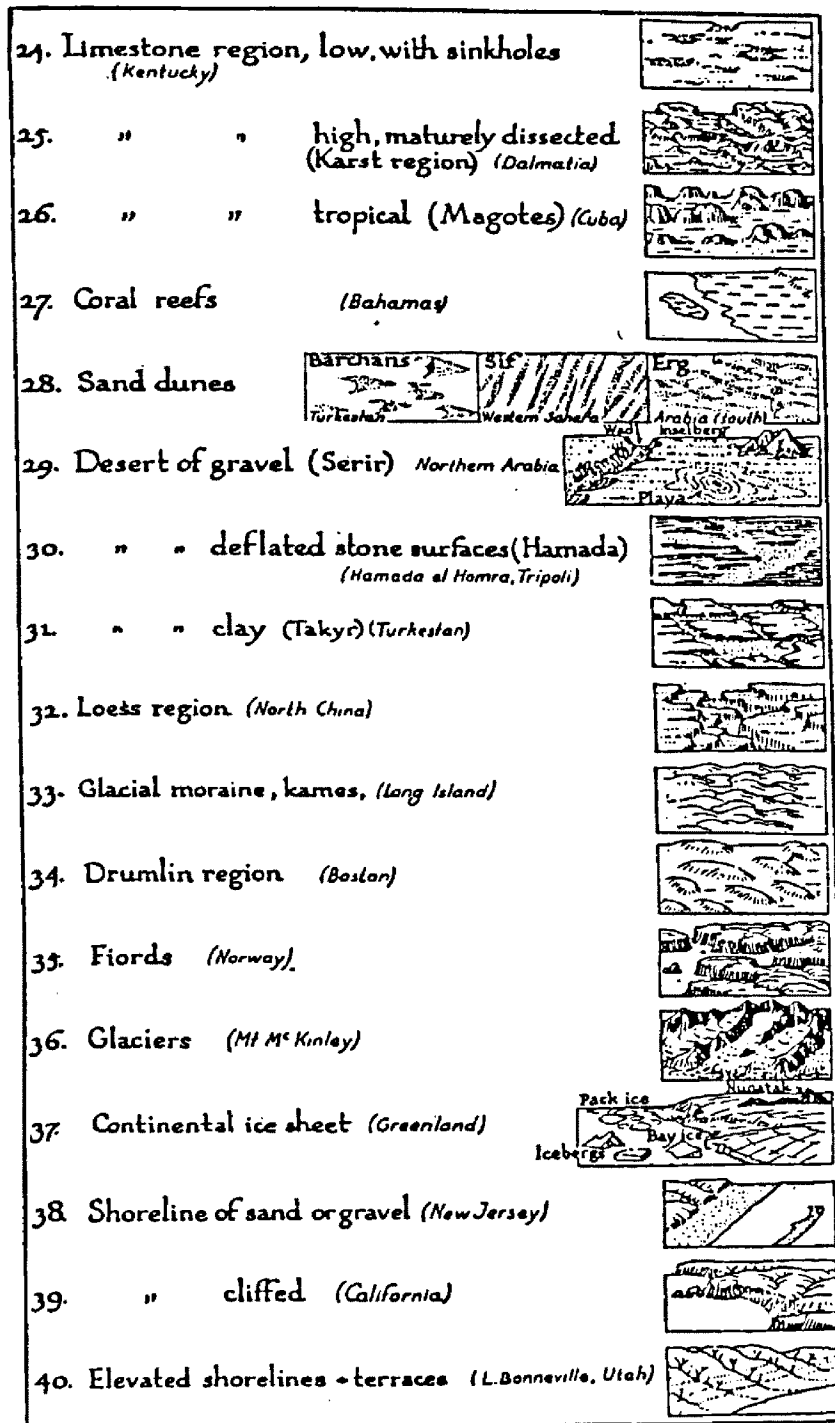


Figure 20 Raisz's Physiographic Symbols

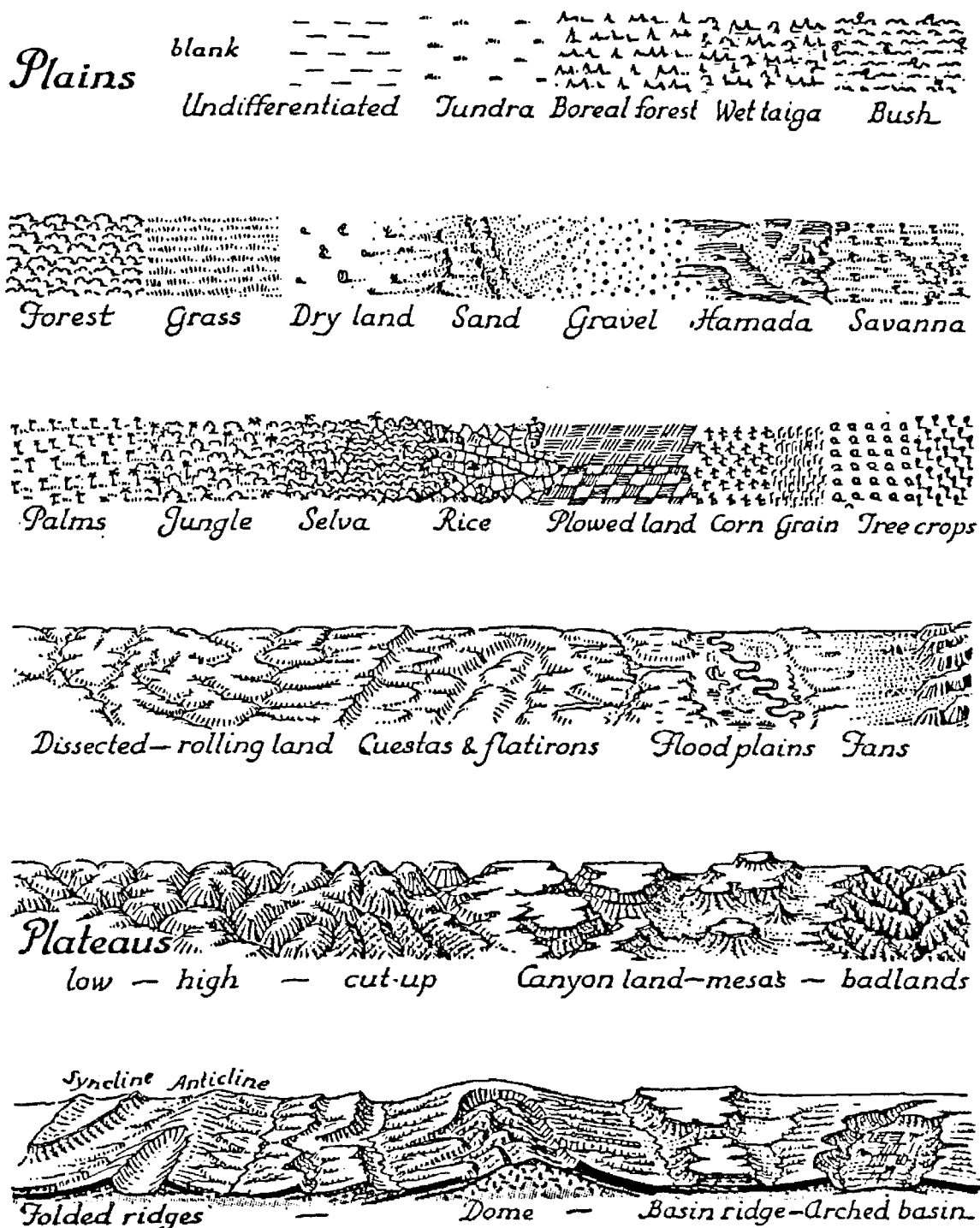


Figure 20 Raisz's Physiographic Symbols<sup>85</sup>

<sup>85</sup>Source: Erwin Raisz, General Cartography (McGraw-Hill Book Co. 1948):120-121.

## LAND FORMS AND LAND SLOPES

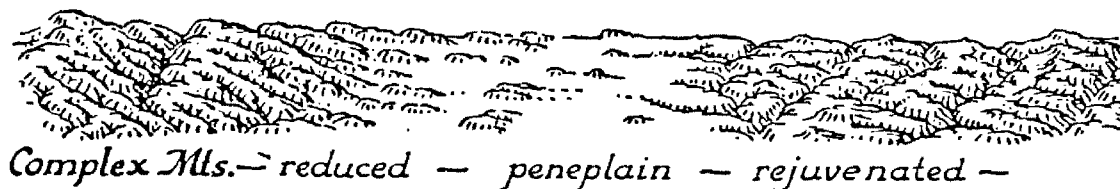
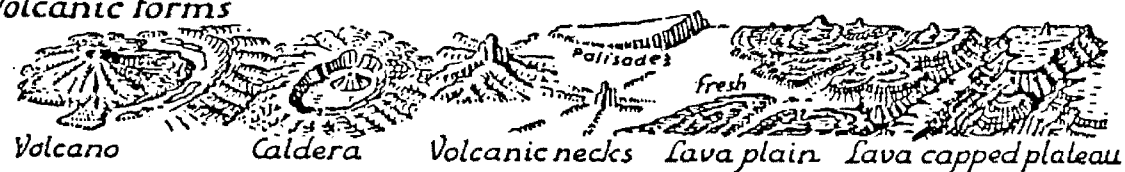
*Volcanic forms**Limestone**Glacial deposits*

Figure 20 Raisz's Physiographic Symbols

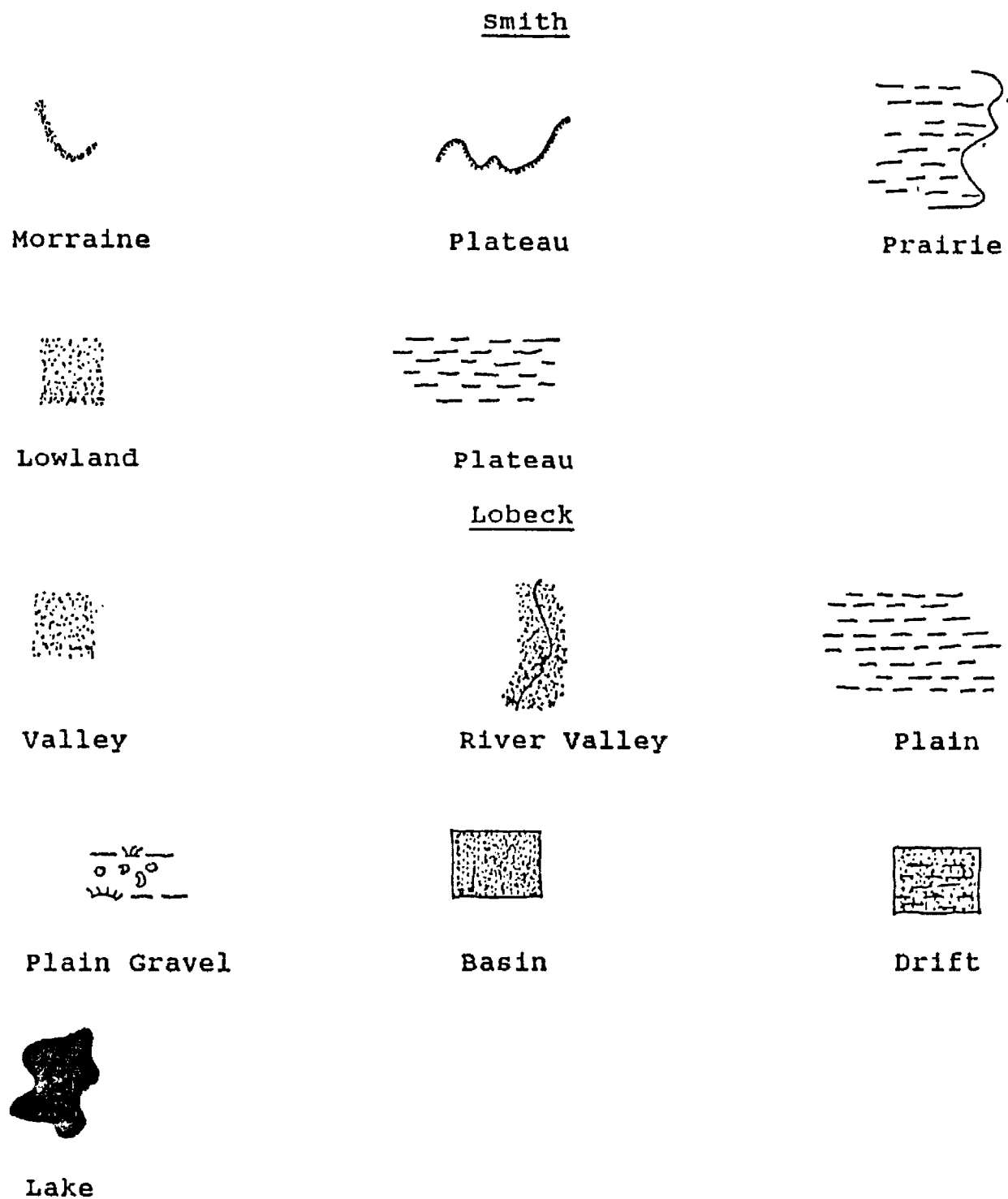


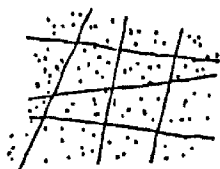
Figure 21 New and Different Symbols

Raisz

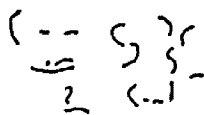
Lake A (Raisz)



Lake B



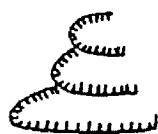
Dykes



Ice



Ice Cap



Drift WI.



Drift Ill.



Glacier



Shoreline



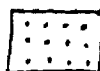
Lava Plain



Sub. Plat.



Salt Pans



Alluvium



Cry. Upland

Figure 21 New and Different Symbols

work appeared among all of the mapped information collected and also through determining that these three men made the biggest impression and changes in physiographic diagramming. Following these guidelines Erwin J. Raisz, A. K. Lobeck, and Guy-Harold Smith were chosen.

### **Contributions by Raisz**

If the collection of diagrams surveyed in this study is any indication of diagram production in general, Raisz emerges the foremost contributor to this cartographic technique/artform. For example, of the 136 diagrams catalogued, sixtyfour, or forty-seven percent, were created by Raisz.

One way which the Raisz maps differ from others is in the intricate ways symbols were designed. Mountains provide an example. Raisz has not one, but four different symbols to show mountains: block mountains, folded mountains, dome mountains, and complex mountains. Within each of these categories, there are sub categories; for instance, within the category block mountains are the sub categories; reduced mountains, complex-glaciated mountains, complex-reduced mountains, and peneplain-rejuvenated mountains.

Raisz has followed this same line with all other symbols, i.e. plains, plateaus, volcanic forms, limestone,



glacial, desert and others (Figure 20).<sup>86</sup> There is no other author of physiographic diagramming who has created or used such a systematic approach to this cartographic form.

Raisz's best work was completed in black, not brown ink; it was usually done at a scale of 1:1,000,000 or smaller. There were a few exceptions to this; in these particular cases, I believe the maps were often more on the order of sketch maps than physiographic diagrams. The color black has more contrast and tends to give a sharper image, while the brown does not appear as sharp in the majority of cases. Raisz rarely mentioned the type of map projection used, but his work is typically so busy that the absence of this information could go by easily without being noticed.

### **Contributions by Lobeck**

One of the first people to use physiographic diagramming, A. K. Lobeck, used this form of mapping almost as if it were a block diagram (for which he was so famous), the main difference being use of a smaller scale (see figure 2, p. 5). Many of Lobeck's drawings are catalogued in this study. It is easily seen that Lobeck's main area of

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<sup>86</sup>All of Raisz's symbols can be seen in the two tables in figure 20, Table of Raisz's Physiographic Symbols. Both tables were taken from different editions of Raisz's General Cartography.

interest was in the portrayal of large-scale tracts of land with underlying geology present.

The information collected in the survey portion of this study shows that Lobeck produced some fine work. He introduced several new or different symbols; he used dots to show valley floors, basins, and glacial drift areas.

A problem in viewing Lobeck's works is that the differences between his block diagram, landscape sketches, and physiographic diagrams are sometimes not very great; this makes identification difficult. From information gathered in the survey, it is apparent that Lobeck's organization or systematization of symbols is not as refined as Raisz's.

#### **Guy-Harold Smith Contributions**

The physiographic diagrams of Guy-Harold Smith are quite different from those of either Lobeck or Raisz. Smith never used as many symbols as Raisz or Lobeck, but in a way this was fitting because, as already noted, his diagrams are much less congested than those of the other two authors. Smith's work is clear, concise, and easily read (see figure 18 p. 73). When first viewing one of Smith's diagrams, it was noted that the symbols seem to be on the small side and the diagram not entirely filled with ink. After a period of viewing and studying these works, they were found to be very pleasurable to read due to the

lack of apparent clutter. It has been noted that Smith may have only used three main symbols: mountains, plains, and plateaus. With the exception of one diagram, all of Smith's work was completed at a scale smaller than 1:1,000,000.

### **Other Elements**

The following is an analysis of selected data from the survey form. Out of 136 maps surveyed, 115 used a horizontal scale and of these 6 were at a scale greater than 1:1,000,000, all the remaining diagrams utilizing scale were smaller scale than 1:1,000,000. There was no common scale, each map varying with the amount of area being covered. This promotes the conclusion that physiographic diagrams are designed at small scales, 1:1,000,000 or smaller.

It was found that only fifty-four, less than half, of the maps surveyed used a map coordinate system in some fashion. In some cases, this grid was only to be found superimposed over the areas of ocean.

It is quite interesting to note that of the three different types of lettering--leroy, photo-mechanical, and hand-lettering--ninety-eight maps used hand lettering, twenty-three leroy, and four used photo mechanical. Some maps did not use just one kind of lettering, i.e. the legends were done in leroy or photo mechanical and the

place names were hand lettered, while physical features were hand lettered or produced by leroy.

The most widely used color is black with 105 maps using it. Brown was found in sixteen maps and blue in six, in oceans only.

### **Summary**

A survey form was created to collect information about each map or physiographic diagram. This information was then entered into a database program for storage and retrieval. Lobeck, Raisz, and Smith were the authors who produced most diagrams with fourteen, sixtyfour, and fifteen respectively. Mountains, plains, and plateau were found to be the most widely used symbols. Raisz was found to produce realistic symbols most consistently even though his symbols were evaluated second. The other authors had more variation in their realism scores but less consistency. Since Raisz's standardized set of symbols was the best available, it was used as a basis for comparison in this paper. Neither Lobeck nor Smith ever produced such a list.

It could be said that Lobeck gave this form its start, Raisz did the most to explore new and different symbol types and to record his findings, and Smith brought a beautiful artistic ease to the creation of diagrams, rendering them more legible.

## Chapter 5

### Summary and Conclusions

The development of physiographic diagramming is a remarkable story which spans the entire history of cartography. Attempts to represent terrain appear on some of the earliest maps in existence. Babylonian clay tablets bore maps with loaf-like drawings representing mountains. Chinese, Greek, and Roman maps occasionally contained similar representations as did maps produced in Europe during the Middle Ages, the Renaissance, and the Age of Exploration. While these drawings could scarcely be compared with the elegant physiographic diagrams produced by cartographers in the United States during this century, they reveal a long term desire of cartographers and geographers to represent landforms on maps.

Hachures (many short lines drawn in the direction of the slope) exemplifies one attempt made during the eighteenth century to reproduce landforms on maps. If drawn by a master, the result gave the impression of a view of the earth as seen from directly above. Executed

with less skillful hands the product resembled dust-bunnies or hairy caterpillars.

A more successful solution for representing landforms on maps, introduced during the nineteenth century, was the use of contour lines which represented constant elevations above sea level. This approach enjoyed scientific precision since careful measurements were involved in the creation of the maps. Moreover, the resulting symbols were amenable to interpretation--with training, map readers could learn to use the shape and spacing of contours to gain a rough visualization of the land. This, of course, is the form of map symbolism used for representing landforms most prominently used in map making today. Most government topographic surveys produce maps which employ contours. Still, the actual pictures of the landforms were missing from such maps. Particularly geologists, geomorphologists, and physiographers, not to mention explorers and surveyors, continued to hope for more visually correct representations--ones that were perhaps less scientifically accurate, but more artistically correct.

Part of the reason that accurate and artistically elegant physiographic diagrams were not produced during the early years of cartography is because several essential concepts and procedures had not been invented yet. For one, the methods used for depicting objects as seen

from vantage points above the earth had not been devised. Except for a few unnotable exceptions, the concepts involved in perspective drawing did not emerge in the world of art and science until the Renaissance when it was first used to depict buildings and other human structures. Furthermore, the use of perspective was not introduced into landscape painting until fairly late in the Renaissance, and even then it did not seem to occur to cartographers that the technique might be used to further science rather than art.

The first cartographic application of perspective landscape drawing emerged during the Age of Exploration. Late during this period landscape artists and natural history draftsmen often accompanied expeditions to record the landscapes and fauna found along the way. Often, the hardships and pressures of time imposed by their adventures reduced such art works from paintings to mere pencil sketches. Ultimately, many of the scientists and expedition leaders of the time became accomplished at producing field sketches. Many examples of field sketches are recorded in the scientific literature of the nineteenth century.

Only a short step would seem to exist between field sketching and physiographic diagramming. Both involve the depiction of landforms as seen obliquely from above. One is produced on a blank sheet of paper, the other on a map.

However, the story takes several interesting side trips before that transition was made. At the turn of the twentieth century, geomorphologists and physiographers were not only interested in the way landforms looked at the surface; they were also interested in the way the surface features related to the underlying geological structure. One invention which helped to depict this relationship was the geological cross section. A geological crossection is produced first by creating a profile (a line on a piece of paper representing the surface of the ground as seen from the side). Next, the underlying strata are drawn into the diagram depending upon their "strike and dip" (the direction and angle that they penetrate beneath the surface of the earth). Finally, each geologic structure is given a textured symbol which has been classified according to the type of geologic material involved. The resemblance between the profile of a geological crossection and the appearance of a field sketch is obvious. Indeed, the literature of the time has examples of crossections onto which field sketches were superimposed--usually in the form of a narrow strip of land extending away from the profile.

A block diagram is virtually nothing more than one or more geological crossections drawn onto the side(s) of a block, the surface of which contains a sketch of the existing landforms. The important marriage of ideas which



occurred with this invention was the notion that the block could be drawn precisely to perspective and all of the surface features could be positioned in appropriate perspective on the surface of the block in perfect relation to one another. The inventor of the block diagram seems to be obscured from history. Nevertheless, the refinement of the art seems to have been the responsibility of three American researchers--Grove Karl Gilbert, William Morris Davis, and Douglas W. Johnson. In particular, William Morris Davis was responsible for formalizing the concept and introducing it into the classroom. At this point the seeds for the development of physiographic diagramming were planted.

One of Davis' students was Douglas W. Johnson became a teacher at Columbia University during the early 1900's. Among other subjects he was responsible for teaching field sketching and block diagramming to his geology students. Toward the end of World War I, Johnson became involved in publishing a book titled Battlefields of the World War (see page 59). The book contained a series of block diagrams used to illustrate battlefields; since the geologic crosssections were not needed, they were left out. The result was for all practical purposes the same as a physiographic diagram. Most of the diagrams were drafted by three of Johnson's students--Armin K. Lobeck, Samuel H. Knight, and Fredrick K. Morris.

Armin K. Lobeck is attributed with inventing physiographic diagramming. During the last months of World War I he took a position with the Department of State. His job was to prepare physiographic diagrams of potential theaters of war. Thus began a lustrous career during which he drew and published many physiographic diagrams. The seed had germinated and taken root.

While many cartographers have drawn physiographic diagrams, three individuals emerge as having been responsible for the continued development and perfection of the technique. These individuals were Armin K. Lobeck, Erwin J. Raisz, and Guy-Harold Smith. Lobeck is not only attributed with having invented the art form, he was instrumental in extending the method to drawing maps of areas scaled to continental proportions (Africa, North America, Europe, and the like). Raisz did the most to systematize and develop the symbols used to produce the diagrams. He attempted to elevate physiographic diagramming from an art to a science, and in many regards he succeeded. Smith produced elegant yet simple diagrams which tended to set the style for most of the physiographic diagrams that have been produced in recent years.

Many cartographers have produced physiographic diagrams. In the research for this paper twenty four authors were assessed; they and others have added to the body of physiographic diagrams but none contributed to the

growth of the technique as much as Lobeck, Raisz, and Smith. All three continued to ply their trade until they passed on, producing work which remained consistent with the forms they had invented. Smith, in his later work, experimented with adding landform symbols to other types of maps, besides physiographic diagrams.

In the course of this study little was found which came after the three major contributors departed. There may be limited use of physiographic diagramming in texts but as far as individual maps, those days are gone. The diagrams have been replaced by topographic maps, the use of satellite imagery, and Geographic Information Systems, methods which create maps that are mostly quicker and easier to produce but not as pleasing to read.

Physiographic diagrams as produced by the masters sometimes appear as landform sketches but at a smaller scale; they always employ symbolic representation of one or several types of landforms. They are usually done in black or brown ink, and portray relief by using a single direction for illumination and shading. They are artistic renderings of scientific and technical information.

Of the symbols catalogued, mountains, plains, plateaus, and deserts have been used most frequently. These have varied slightly between author, but they always seemed to maintain a degree of realism which, when measured, was realistic up to as much as seventy-five

percent of the time (table 3 pg. 82). In terms of number of maps catalogued for this study, Erwin Raisz had sixty-four, Guy-Harold Smith had fifteen, and Armin Lobeck had fourteen.

Erwin Raisz was the only author who produced and upgraded a systematic listing of symbols, this list became a comparison for all others (figure 20). Raisz produced variations on these symbols as they evolved, while the other authors produced variations of their own (figure 21).

The information that this thesis presents regarding the history of the development of physiographic diagramming is believed to be essentially accurate and complete. This does not mean that there is nothing new left to be learned about maps of this type. Only seven libraries were researched. While it is likely that a representative set of physiographic diagrams was found in the process, it is certainly possible that discoveries of additional varieties and sub-types might be found if the research were continued. The sampling of diagrams viewed led to the conclusion that Armin K. Lobeck, Erwin J. Raisz, and Guy-Harold Smith were the principal contributors to the art form. Additional research could possibly reveal other individuals who made note worthy contributions.

Little or no consideration was given to physiographic diagramming outside of the United States other than to affirm that it was an American invention. It would be interesting to learn if the technique was diffused to Europe, Asia, Latin America, of Africa, and, if so, what variations or forms developed in those places. Research along these lines might also produce new information regarding physiographic diagramming.

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